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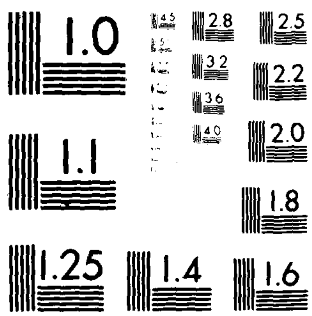

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THE UNDERWATER SHOCK ANALYSIS CODE (USA-VERSION 3)

A Reference Manual

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Lockheed Missiles and Space Co., Inc.
3251 Hanover Street
Palo Alto, California 94304

15 September 1980

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This report constitutes a reference manual for the third version of the Underwater Shock Analysis (USA) Code, a computer program for calculation of the transient response of a totally or partially submerged structure to a spherical shock wave of arbitrary pressure profile and source location. The code considers the structure to be linear-elastic and treats the surrounding fluid as an infinite acoustic medium. A discrete-element (finite-element, finite-

20. ABSTRACT (Continued)

difference) computational model is used for the structure, while the computational model for the fluid is based upon either of the Doubly Asymptotic Approximations.

PREFACE

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SECTION I

INTRODUCTION

This report documents the third version of a computer program, the Underwater Shock Analysis (USA) Code, that calculates the transient response of a totally or partially submerged structure to a spherical shock wave of arbitrary pressure-profile and source location. The structure is considered to be linear-elastic and the surrounding fluid is treated as an infinite or semi-infinite acoustic medium. The computational model for the structure is constructed through the use of an auxiliary discrete-element (finite-element, finite-difference) code of choice [1,2], while that for the fluid is constructed through the use of the Doubly Asymptotic Approximation (DAA_1) or the Improved Doubly Asymptotic Approximation (DAA_2) [3,4].

As implied above, this manual constitutes a revision of [5], the original manual for the USA Code. In addition to various maintenance upgrades introduced into the code since it was first developed, the following extensions have been incorporated: 1) Fluid surface elements for wet-surface segments of revolution that permit a circumferential expansion of structural surface motions into an arbitrary number of Fourier components; this allows the inclusion of both beam-like and bar-like motions of the structure as a special case; 2) An imaging formulation that extends DAA analysis to problems involving partially submerged structures and structures totally submerged near the fluid's free surface; 3) A model for the effects of bulk cavitation on incident-wave excitation that provides a complete description of fluid-particle velocity consistent with the occurrence of surface cutoff; 4) The introduction of the DAA_2; and 5) Out-of-core processing of the fluid equation system.

1.1 DOUBLY SYMPTOTIC APPROXIMATION

The principal advantage of the DAA_1 and DAA_2 is that they model the acoustic medium surrounding the structure as a membrane covering the wet surface of the structure. Hence fluid motion is described merely in terms of wet-surface response variables, which are then linked by compatibility relations to the structural response variables. Furthermore, this description is a simple matrix ordinary differential equation with desirable computational properties.

The principal disadvantage of the DAA_1 is that it constitutes an approximation to the "exact" boundary-element representation of the surrounding medium [6,7]. The DAA_1 does approach exactness for both high-frequency (early-time) and low frequency (late-time) structural motions, however, and effects a smooth transition between the two asymptotes. In addition, it has exhibited satisfactory accuracy in a variety of check calculations [4,6,8]. Hence, in view of its desirable computational properties, the DAA_1 is considered suitable for engineering analysis.

The DAA_2 is an improved approximation that is based upon the DAA_1; however, it can describe the intermediate frequency range better than the DAA_1. Computationally it has been used to study the response of the infinite cylindrical shell under a plane wave step loading in which significant improvements in accuracy have been noted. Analytical studies of spherical shell response [4] also show such marked improvement.

1.2 STAGGERED SOLUTION PROCEDURE

The governing matrix equation for structural response is a second-order differential equation in time, while that for fluid response is a first-order ordinary differential equation. Simultaneous solution of these equations by direct step-by-step numerical integration, however, is unacceptably expensive. Hence the USA code utilizes a staggered solution procedure [9] for step-by-step solution of the equations in time.

Now a staggered solution procedure involves a response extrapolation at each time step, which usually leads to numerical instability for time increments exceeding a critical value. Because this critical value may be unacceptably small for many computations, the governing equations for fluid response have been modified in such a way that unconditional stability is achieved. Thus, through avoidance of both direct simultaneous solution and conditional stability constraints, highly efficient computation is possible for the greatest variety of cases.

As an illustration of the capabilities of USA, a transient response calculation has been performed for a 2490 degree-of-freedom (DOF) structural model with a stiffness-matrix average half-bandwidth of 85 DOF. The central-processing-unit (CPU) time on a Univac 1108 required for the 280 time-step calculation (with a single change in time increment during the calculation) was 28 minutes. The corresponding time on a CDC 6600, on which the code also operates, would be about 10 minutes.

1.3 INPUT/OUTPUT

The USA Code requires three types of input data in order to perform its function. First, structural mesh-geometry, mass-matrix and stiffness-matrix data must be provided by the structural analysis code used by the analyst. Second, fluid mesh-geometry and boundary-element data must be furnished. Finally, location of the fluid's free surface, charge standoff, incident pressure-profile, and time integration specifications must be provided.

The code, in its turn, outputs structural displacement and velocity histories, and fluid pressure histories for the wet surface. Response data post-processors furnish pseudo-velocity shock spectra, and response-history and shock-spectrum plots. In addition, post-processors embedded in the structural analysis code may be used to obtain, for example, stress and strain response histories, as well as stress/strain-history and stress/strain-computer plots. As

currently configured, the USA Code can routinely handle problems with as many as 3000 Structural and 400 fluid DOF within a core allocation of 65000 decimal words.

1.4 SPECIAL FEATURES

A number of special features are incorporated in the code. First, a capability has been provided to handle a fluid mesh on the wet surface that is not coincident with the surface mesh for the structural model. This permits, for example, the use of a refined structural mesh in a region of high stress gradients, even though a relatively coarse mesh is retained for the fluid.

Second, options for variable-increment time integration and computation restart are furnished. The former allows the use of small time increments during periods where the response is expected to be varying rapidly in time, and the use of large time increments for periods characterized by a slowly varying response. The latter permits the division of a response computation into segments, so that the analyst may examine the results at selected points along the way. Such examination is facilitated by the use of the "printer-plot" routine that augments the usual printout data with response plots "drawn" by the printer.

Third, the code incorporates fluid boundary elements for both general and body-of-revolution wet-surface geometries [10]. This feature is especially useful for compartment-by-compartment analysis of a submarine. Such an analysis utilizes a general-structure discrete-element model of a particular compartment of interest, with the remainder of the submarine modeled as a bar/beam. Hence a detailed analysis of an entire submarine may be performed with several discrete-element models of moderate size, avoiding the use of a single gigantic model.

Fourth, the analyst can use either the DAA_1 or DAA_2 through input of a single scalar parameter to take advantage of the enhanced accuracy demonstrated by the latter in computations for idealized geometries.

Fifth, out-of-core processing for both the structural and fluid equation systems frees the user from concern over core limitations on the number of structural and fluid elements in his model.

Sixth, free-field shock wave input to the structure is associated with a spherical wave and can be input for use with linear interpolation or cubic spline fitting routines. Pressure histories for exponentially decaying incident waves can be automatically generated. Fluid pressure and particle velocity histories corresponding to the input shock are displayed for the user with the "printer-plot" software mentioned above.

Seventh, routines embedded in USA can be used to facilitate coupling with any linear structural analyzer provided ıat the ´ ffness matrix is made available row by row (or,

column by column). These routines assemble the matrix in the partitioned skylined format required by USA. In addition, the stiffness matrix can be displayed for check purposes.

1.5 SPECIAL NON-FEATURES

Some features of modest complexity have yet to be incorporated into the USA Code. First, an option for automatic time-step integration would free the analyst from having to select integration time increments in accordance with his expectations regarding response behavior. Second, the ability to handle very large problems would be useful in those cases where structural segmentation is not possible. Third, a capability to treat banded structural mass and damping matrices would be helpful, in order to accommodate structural analyzers that produce such matrices. Fourth, a means to handle the matrices produced by acoustic elements based on a pressure formulation [11,12] is desirable, in that such elements permit highly efficient modeling of internal fluid volumes. Finally, a capability to treat localized nonlinear structural behavior, such as that exhibited by nonlinear equipment mounts, would permit highly efficient treatment of such behavior; for widespread nonlinear effects, however, recourse must be made to a fully nonlinear code, such as USA-STAGS [13].

An important feature of greater complexity has yet to be introduced into the code. This is a treatment of hull cavitation, which may substantially affect structural response for incident shock waves of short duration. The introduction of this feature requires the accurate treatment of highly nonlinear phenomena, and presents a challenging task for future work.

SECTION II

THEORY

This section describes the theoretical foundation of the USA Code. It is constructed as an overview, with coverage of details left to referenced papers and reports.

2.1 STRUCTURAL RESPONSE EQUATION

The matrix ordinary differential equation for the dynamic response of a linear-elastic structure is [1]

$$\underset{\sim}{M}_s \, \underline{\ddot{x}} + \underset{\sim}{C}_s \, \underline{\dot{x}} + \underset{\sim}{K}_s \, \underline{x} = \underline{f} \tag{2.1}$$

where $\underline{x}$ is the structural displacement vector, $\underset{\sim}{M}_s$, $\underset{\sim}{C}_s$ and $\underset{\sim}{K}_s$ are the structural mass, damping and stiffness matrices, respectively, $\underline{f}$ is the external force vector, and a dot denotes a temporal derivative. Generally, $\underset{\sim}{M}_s$, $\underset{\sim}{C}_s$ and $\underset{\sim}{K}_s$ are highly banded, symmetric matrices of large order; at present, the USA Code considers $\underset{\sim}{M}_s$ to be diagonal and $\underset{\sim}{C}_s$ to be zero.

For excitation of a submerged structure by an acoustic wave, $\underline{f}$ is given by

$$\underline{f} = -\underset{\sim}{G} \, \underset{\sim}{A}_f \, (\underline{p}_I + \underline{p}_S) \tag{2.2}$$

where $\underline{p}_I$ and $\underline{p}_S$ are nodal pressure vectors for the wet-surface fluid mesh pertaining to the (known) incident wave and the (unknown) scattered wave, respectively, $\underset{\sim}{A}_f$ is the diagonal area matrix associated with elements in the fluid mesh, and $\underset{\sim}{G}$ is the transformation matrix that relates the structural and fluid nodal surface forces. More will be said about $\underset{\sim}{G}$ in the next subsection.

2.2 DAA_1 EQUATION

The Doubly Asymptotic Approximation may be written [3,4]

$$\underset{\sim}{M}_f \, \underline{\dot{p}}_S + \rho c \, \underset{\sim}{A}_f \, \underline{p}_S = \rho c \, \underset{\sim}{M}_f \, \underline{\dot{u}}_S \tag{2.3}$$

where $\underline{u}_S$ is the vector of scattered-wave fluid-particle velocities normal to the structure's wet surface, ρ and c are the density and sound velocity of the fluid, respectively, and $\underset{\sim}{M}_f$ is the symmetric fluid mass matrix for the wet-surface fluid mesh. This matrix is produced by a boundary-element treatment of Laplace's equation for the irrotational flow generated in an infinite, inviscid, <u>incompressible</u> fluid

by motions of the structure's wet surface; it is fully populated with non-zero matrix elements. When transformed into structural coordinates, the fluid mass matrix yields the added mass matrix, which, when combined with the structural mass matrix, yields the virtual mass matrix for motions of a structure submerged in an incompressible fluid [14].

As mentioned in Section I, the approximate relation (2.3) is called "doubly asymptotic" because it approaches exactness in both the high-frequency (early-time) and low-frequency (late-time) limits. For high-frequency motions, $|\dot{\underline{p}}_S| >> |\underline{p}_S|$, so that (2.3) approaches the relation $\underline{p}_S = \rho c \underline{u}_S$, which is the correct limit for short acoustic wavelengths. For low-frequency motions, $|\dot{\underline{p}}_S| << |\underline{p}_S|$, so that (2.3) approaches the incompressible-flow relation $\underset{\sim}{A}_f \, \underline{p}_S = \underset{\sim}{M}_f \, \dot{\underline{u}}_S$, which is the correct limit for long acoustic wavelengths.

For excitation by an incident acoustic wave, $\underline{u}_S$ is related to structural response by the kinematic compatibility relation

$$\underset{\sim}{G}^T \dot{\underline{x}} = \underline{u}_I + \underline{u}_S \tag{2.4}$$

where the superscript "T" denotes matrix transposition. Equation (2.4) expresses the constraint that normal fluid-particle velocity match normal structural velocity on the wet surface of the structure. The fact that the transformation matrix relating those velocities is $\underset{\sim}{G}^T$ follows from the invariance of virtual work with respect to either of the wet surface coordinate systems. Generally, $\underset{\sim}{G}$ is a rectangular matrix whose height greatly exceeds its width, inasmuch as the number of structural DOF usually exceeds considerably the number of fluid DOF.

2.3 INTERACTION EQUATIONS

The introduction of (2.2) into (2.1) and (2.4) into (2.3) yields the interaction equations

$$\begin{aligned} \underset{\sim}{M}_s \ddot{\underline{x}} + \underset{\sim}{C}_s \dot{\underline{x}} + \underset{\sim}{K}_s \underline{x} &= - \underset{\sim}{G} \underset{\sim}{A}_f (\underline{p}_I + \underline{p}_S) \\ \underset{\sim}{M}_f \dot{\underline{p}}_S + \rho c \underset{\sim}{A}_f \underline{p}_S &= \rho c \underset{\sim}{M}_f (\underset{\sim}{G}^T \ddot{\underline{x}} - \dot{\underline{u}}_I) \end{aligned} \tag{2.5}$$

These equations may be solved simultaneously at each time step by the transfer of $-\underset{\sim}{G} \underset{\sim}{A}_f \underline{p}_S$ and $\rho c \underset{\sim}{M}_f \underset{\sim}{G}^T \ddot{\underline{x}}$ to the left sides of their respective equations. Such a procedure is exceedingly expensive, however, because of the large connectivity of the coefficient matrix involved. As mentioned in Section I, efficient computation is possible through the application of a staggered solution procedure that is <u>unconditionally stable</u> with respect to the choice of time increment.

The simplest implementation of the staggered solution procedure recommended in [9] may be effected as follows. $\underset{\sim}{M}_s$ is taken to be diagonal and, to allow for the possibility that $\underset{\sim}{M}_s$ may have zero entries for rotational DOF, $\underset{\sim}{G}$ is constructed such that only the transla-

tional DOF for the structure couple with the fluid DOF [see (2.4)]; then the first of (2.5) may be partitioned to obtain $\underset{\sim}{G}^T\ddot{\underline{x}}$, which may then be introduced into the second of (2.5). Premultiplication of the resulting equation by $\frac{1}{\rho c}\underset{\sim}{A}_f\underset{\sim}{M}_f^{-1}$ then yields

$$\frac{1}{\rho c}\underset{\sim}{A}_f\dot{\underline{p}}_S + (\underset{\sim}{D}_{f1} + \underset{\sim}{D}_S)\underline{p}_S = -\underset{\sim}{A}_f\underset{\sim}{G}^T\underset{\sim}{M}_S^{-1}(\underset{\sim}{C}_S\dot{\underline{x}} + \underset{\sim}{K}_S\underline{x}) - (\underset{\sim}{D}_S\underline{p}_I + \underset{\sim}{A}_f\dot{\underline{u}}_I) \tag{2.6}$$

where $\underset{\sim}{D}_{f1} = \underset{\sim}{A}_f\underset{\sim}{M}_f^{-1}\underset{\sim}{A}_f$ and $\underset{\sim}{D}_S = \underset{\sim}{A}_f\underset{\sim}{G}^T\underset{\sim}{M}_S^{-1}\underset{\sim}{G}\underset{\sim}{A}_f$ are symmetric, and where $\underset{\sim}{M}_S^{-1}$ is a diagonal matrix with each nonzero element given as the reciprocal of the corresponding nonzero element of $\underset{\sim}{M}_S$ and each zero element mirroring the corresponding zero element of $\underset{\sim}{M}_S$. The first of (2.5) and (2.6) are herein termed "the augmented interaction equations".

2.4 SPHERICAL INCIDENT WAVE

Each element of the vectors $\underline{p}_I$ and $\dot{\underline{u}}_I$ for a spherical incident wave are given by

$$p_{Ii}(t) = \frac{S}{R_i}\, p_I\left(t - \frac{R_i - S}{c}\right)$$
$$\dot{u}_{Ii}(t) = \left[\frac{1}{\rho c}\,\dot{p}_{Ii}(t) + \frac{1}{\rho R_i}\, p_{Ii}(t)\right]\gamma_i \tag{2.7}$$

where S is the "charge standoff", i.e., the distance between the origin of the incident spherical wave and the nearest point on the structure's wet surface, R_i is the distance from the origin of the incident spherical wave to the i<u>th</u> fluid node on the wet surface, γ_i is the cosine of the angle between the vector corresponding to R_i and the wet-surface normal at the i<u>th</u> fluid node, and $p_I(t)$ is the incident-wave pressure-profile defined at $R_i = S$. For a shock wave, $p_I(t)$ is discontinuous at $t = 0$ and the $\dot{u}_{Ii}(t)$ contain singularities.

In order to remove shock-wave singularities from $\dot{\underline{u}}_I$ in (2.6), a modified pressure vector is defined as

$$\underline{p}_M = \underset{\sim}{\Gamma}\underline{p}_I + \underline{p}_S \tag{2.8}$$

where $\underset{\sim}{\Gamma}$ is a diagonal matrix with direction-cosine elements γ_i. The introduction of (2.8) into (2.6) and the first of (2.5), followed by utilization of the second of (2.7) then yields the modified, augmented, interaction equations

$$\underset{\sim}{M}_S\ddot{\underline{x}} + \underset{\sim}{C}_S\dot{\underline{x}} + \underset{\sim}{K}_S\underline{x} = -\underset{\sim}{G}\underset{\sim}{A}_f[\underline{p}_M + (\underset{\sim}{I} - \underset{\sim}{\Gamma})\underline{p}_I] \tag{2.9}$$

$$\frac{1}{\rho c}\underset{\sim}{A}_f\dot{\underline{p}}_M + (\underset{\sim}{D}_{f1} + \underset{\sim}{D}_S)\underline{p}_M = -\underset{\sim}{A}_f\underset{\sim}{G}^T\underset{\sim}{M}_S^{-1}(\underset{\sim}{C}_S\dot{\underline{x}} + \underset{\sim}{K}_S\underline{x}) - \underset{\sim}{H}\underline{p}_I$$

in which $\underset{\sim}{I}$ is the identity matrix, and

$$\underset{\sim}{H} = \underset{\sim}{D}_s - (\underset{\sim}{D}_s + \underset{\sim}{D}_{f1} - \frac{1}{\rho} \underset{\sim}{A}_f \underset{\sim}{R}^{-1}) \underset{\sim}{\Gamma} \tag{2.10}$$

where $\underset{\sim}{R}$ is the diagonal matrix formed by the distances R_i. Equations (2.9) (with $\underset{\sim}{C}_s = 0$) are the equations solved by the USA Code to determine the structural responses $\underline{x}$ and $\underline{\dot{x}}$, and the wet-surface pressures $\underline{p} = (\underset{\sim}{I} - \underset{\sim}{\Gamma})\, \underline{p}_I + \underline{p}_M$.

2.5 FREE SURFACE EFFECTS

When a structure is partially submerged, or when a totally submerged structure lies near the free surface of a semi-infinite fluid, imaging techniques may be utilized to ensure that the total pressure vanishes at the free surface. (This implies that the effects of gravity are negligible in this class of problems, which they generally are.) In this case, the interactive system consists of an infinite fluid domain, the structure S_+, and its image S_- (see Figure 2-1). The incident wave now consists of a (positive) primary wave plus a (negative) image wave, the latter emanating from the image of the primary wave's origin. Zero pressure at the free surface is therefore maintained if the motions of S_- are constrained to be opposite to those of S_+.

The kinetic energy T_s, the Rayleigh dissipation function D_s, the potential energy V_s, and the work potential Π_s, for the structural system $S_+ + S_-$ are given by

$$\begin{aligned} T_s &= \tfrac{1}{2} (\underline{\dot{x}}_+^T \underset{\sim}{M}_s \underline{\dot{x}}_+ + \underline{\dot{x}}_-^T \underset{\sim}{M}_s \underline{\dot{x}}_-) \\ D_s &= \tfrac{1}{2} (\underline{\dot{x}}_+ \underset{\sim}{C}_s \underline{\dot{x}}_+ + \underline{\dot{x}}_-^T \underset{\sim}{C}_s \underline{\dot{x}}_-) \\ V_s &= \tfrac{1}{2} (\underline{x}_+^T \underset{\sim}{K}_s \underline{x}_+ + \underline{x}_-^T \underset{\sim}{K}_s \underline{x}_-) \\ \Pi_s &= -\underline{x}_+^T \underline{f}_+ - \underline{x}_-^T \underline{f}_- \end{aligned} \tag{2.11}$$

The appropriate constraints are $\underline{x}_- = -\underline{x}_+$ and $\underline{f}_- = -\underline{f}_+$, so that (2.11) become

$$\begin{aligned} T_s &= \underline{\dot{x}}_+^T \underset{\sim}{M}_s \underline{\dot{x}}_+ \\ D_s &= \underline{\dot{x}}_+^T \underset{\sim}{C}_s \underline{\dot{x}}_+ \\ V_s &= \underline{x}_+^T \underset{\sim}{K}_s \underline{x}_+ \\ \Pi_s &= -2\, \underline{x}_+^T \underline{f}_+ \end{aligned} \tag{2.12}$$

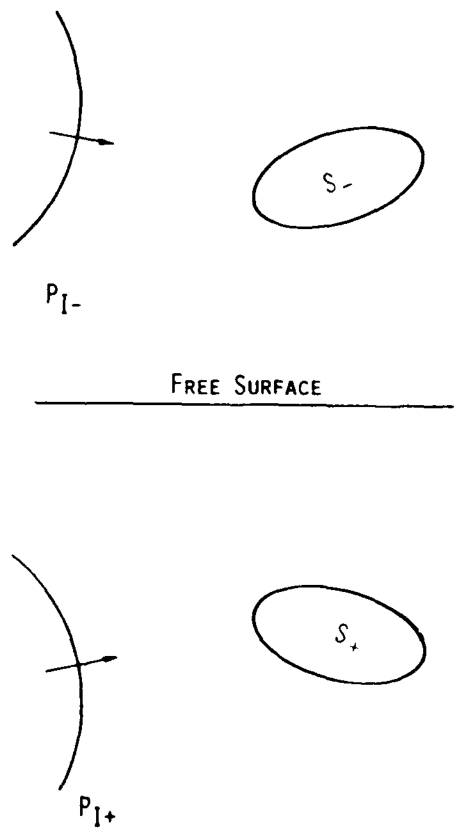

Figure 2-1 Image Technique for Free Surface

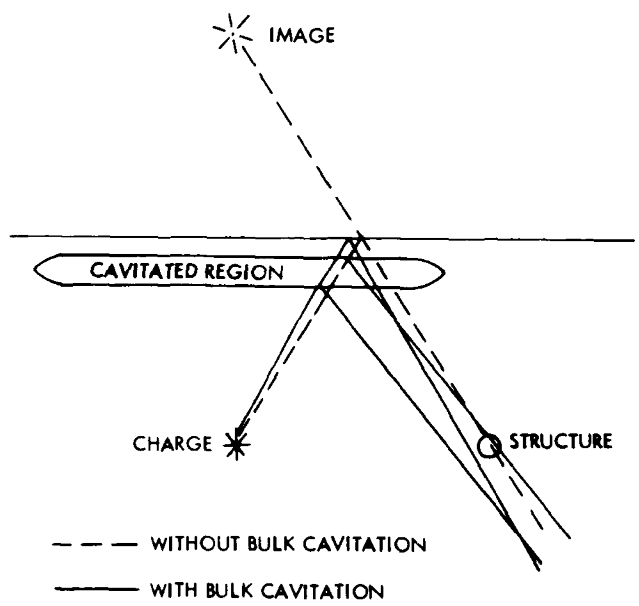

Figure 2-2 Free Field Ray Diagram

The DAA kinetic energy T_f and work potential Π_f for the fluid system may be written as

$$\begin{aligned} T_f &= \tfrac{1}{2}\, \underset{\sim}{u}_S^T \underset{\sim}{M}_f\, \underset{\sim}{u}_S \\ \Pi_f &= -\overset{*}{\underset{\sim}{u}}{}_S^T \underset{\sim}{A}_f\, \underset{\sim}{p}_S - \frac{1}{\rho c}\, \overset{*}{\underset{\sim}{u}}{}_S^T \underset{\sim}{M}_f\, \dot{\underset{\sim}{p}}_S \end{aligned} \tag{2.13}$$

where

$$\underset{\sim}{M}_f = \begin{bmatrix} \underset{\sim}{M} & \underset{\sim}{M}' \\ \underset{\sim}{M}' & \underset{\sim}{M} \end{bmatrix}, \quad \underset{\sim}{A}_f = \begin{bmatrix} \underset{\sim}{A} & \underset{\sim}{0} \\ \underset{\sim}{0} & \underset{\sim}{A} \end{bmatrix} \tag{2.14}$$

and an asterisk denotes temporal integration. The submatrix $\underset{\sim}{M}$ accounts for added mass coupling between wet-surface elements on S_+ and, similarly, between elements on S_-; M' accounts for added mass coupling between elements on S_+ and elements on S_-. The constraints for the fluid system are

$$\underset{\sim}{u}_S = \begin{bmatrix} \underset{\sim}{I} \\ -\underset{\sim}{I} \end{bmatrix} \underset{\sim}{u}_{S+}, \quad \underset{\sim}{p}_S = \begin{bmatrix} \underset{\sim}{I} \\ -\underset{\sim}{I} \end{bmatrix} \underset{\sim}{p}_{S+} \tag{2.15}$$

so that (2.13) becomes

$$\begin{aligned} T_f &= \underset{\sim}{u}_{S+}^T (\underset{\sim}{M} - \underset{\sim}{M}')\, \underset{\sim}{u}_{S+} \\ \Pi_f &= -2\, \overset{*}{\underset{\sim}{u}}{}_{S+}^T [\underset{\sim}{A}\, \underset{\sim}{p}_{S+} + \frac{1}{\rho c} (\underset{\sim}{M} - \underset{\sim}{M}')\, \dot{\underset{\sim}{p}}_{S+}] \end{aligned} \tag{2.16}$$

The application of Lagrange's equation [15] to (2.12) and (2.16) now yields

$$\begin{aligned} \underset{\sim}{M}_s \ddot{\underset{\sim}{x}}_+ + \underset{\sim}{C}_s \dot{\underset{\sim}{x}}_+ + K_s\, \underset{\sim}{x}_+ &= \underset{\sim}{f}_+ \\ \frac{1}{\rho c} (\underset{\sim}{M} - \underset{\sim}{M}')\, \dot{\underset{\sim}{p}}_{S+} + \underset{\sim}{A}\, \underset{\sim}{p}_{S+} &= (\underset{\sim}{M} - \underset{\sim}{M}')\, \dot{\underset{\sim}{u}}_{S+} \end{aligned} \tag{2.17}$$

Also, (2.2) and (2.4) must be modified to include the effects of both the incident primary and image waves. This gives

$$\begin{aligned} \underset{\sim}{f}_+ &= -\underset{\sim}{G}\, \underset{\sim}{A}\, (\overset{+}{\underset{\sim}{p}}_{I+} + \overset{-}{\underset{\sim}{p}}_{I+} + \underset{\sim}{p}_{S+}) \\ \underset{\sim}{G}^T \dot{\underset{\sim}{x}}_+ &= \overset{+}{\underset{\sim}{u}}_{I+} + \overset{-}{\underset{\sim}{u}}_{I+} + \underset{\sim}{u}_{S+} \end{aligned} \tag{2.18}$$

where, e.g., $\overset{-}{\underset{\sim}{p}}_{I+}$ denotes incident-wave pressure on S_+ associated with the image wave. The introduction of (2.18) into (2.17) then yields the doubly asymptotic interaction equations for problems involving a free surface

$$\underset{\sim}{M}_s\, \ddot{\underline{x}}_+ + \underset{\sim}{C}_s\, \dot{\underline{x}}_+ + \underset{\sim}{K}_s\, \underline{x}_+ \;=\; \underset{\sim}{G}\, \underset{\sim}{A}\, (\underline{p}^+_{I+} + \underline{p}^-_{I+} + \underline{p}_{S+})$$

$$(\underset{\sim}{M} - \underset{\sim}{M})\, \dot{\underline{p}}_{S+} + \rho c\, \underset{\sim}{A}\, \underline{p}_{S+} \;=\; \rho c\, (\underset{\sim}{M} - \underset{\sim}{M}')\, (\underset{\sim}{G}^T\, \ddot{\underline{x}}_+ - \underline{u}^+_{I+} - \underline{u}^-_{I+}) \tag{2.19}$$

A comparison of (2.19) with (2.5) reveals that the effects of the free surface are embodied in the image-wave pressure and fluid-particle-velocity vectors, and in the modified added-mass matrix.

Finally, augmentation of (2.19) to secure unconditional stability, followed by introduction of the modified pressure [cf. (2.8)]

$$\underline{p}_M \;=\; \underset{\sim}{\Gamma}^+_+\, \underline{p}^+_{I+} + \underset{\sim}{\Gamma}^-_+\, \underline{p}^-_{I+} + \underline{p}_{S+} \tag{2.20}$$

to remove shock-wave singularities, proceeds as described in Subsections 2.3 and 2.4. The modified, augmented interaction equations corresponding to (2.9) for the infinite fluid medium are then readily obtained.

It is important to mention at this point that the DAA formulation just described does not account for high-frequency scattered waves from S_- that impinge upon S_+. For most floating structures, such waves are not generated, as the wet surfaces of S_+ and S_- usually intersect to form a convex surface; they are generated, however, for a totally submerged structure lying near the free surface. Even so, it has been shown that, as far as structural response is concerned, the effects of the scattered wave are generally negligible [16]. In other words, the response is basically driven by the incident primary and image waves.

2.6 BULK CAVITATION

In the absence of bulk cavitation, the imaging method serves as a useful device to model the reflection of free-field waves from the fluid's free surface. The occurrence of bulk cavitation near the surface, however, changes that simple acoustic reflection problem into a complex reflection-refraction problem, as indicated in Figure 2-2. If refraction distortions produced by a relatively thin cavitated region are not too severe, however, bulk cavitation effects will still appear to the structure as emanating from an image source.

Experimental records of free-field pressure histories for compact charges exhibit the behavior shown in Figure 2-3 [17]. The dashed line denotes the history produced by a negative-image model, while the horizontal line indicates that the effect of bulk cavitation is to "cut off" the pressure at a cavitation threshold. The approximate treatment introduced here involves pre-examination of the image-based free-field pressure at the

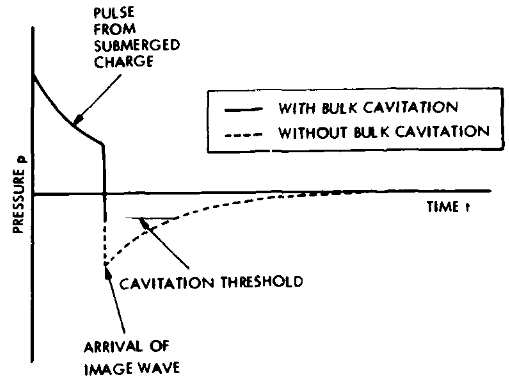

Figure 2-3 Free-Field Pressure as a Result of Free-Surface Reflection

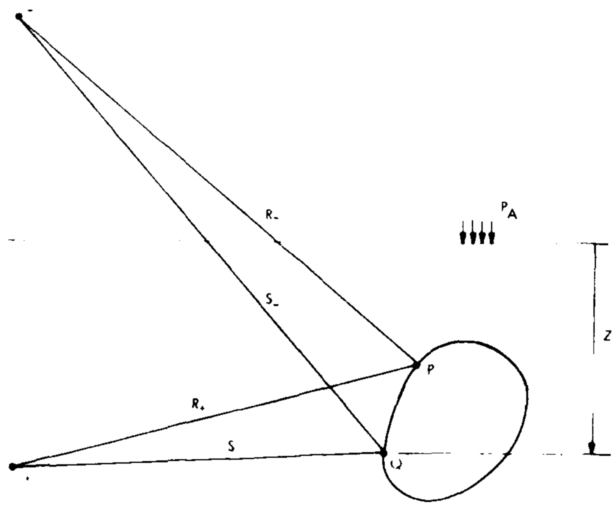

Figure 2-4 Geometry of Primary and Image Waves

standoff point, i.e., the point on the submerged structure closest to the charge. Whenever that pressure becomes negative to the extent that its magnitude exceeds the absolute ambient pressure at that depth, a positive contribution is incorporated into the negative-image source so that the free-field pressure at the standoff point never dips below the cavitation threshold. When the structure's overall dimensions are small relative to the distance from the structure to the cavitated region, the effects of the positive contribution will not vary appreciably in the vicinity of the structure.

The preceding discussion leads to the following development. The two-source model of Figure 2-4 yields as the free-field pressure at any point $\underline{P}$

$$p_{\underline{P}}(t) = \frac{S}{R_+} p_+ \left(t - \frac{R_+ - S}{c}\right) + \frac{S}{R_-} P_- \left(t - \frac{R_- - S}{c}\right) \tag{2.21}$$

where $p_+(t) = p_-(t) = 0$ for $t < 0$. At the standoff point, (2.21) becomes

$$p_Q(t) = p_+(t) + \frac{S}{S_-} p_- \left(t - \frac{S_- - S}{c}\right) \tag{2.22}$$

Now $p_-(t) = -p_+(t)$ as long as the resulting $p_Q(t)$ exceeds the cavitation threshold so that "cutoff" does not occur; otherwise, $p_Q(t)$ remains at the threshold value $-(p_A + \gamma Z)$ where p_A is atmospheric pressure and γ is the fluid's weight density. Hence, during the "cutoff period",

$$p_-(t) = -\frac{S_-}{S} \left[p_+ \left(t + \frac{S_- - S}{c}\right) + p_A + \gamma Z\right] \tag{2.23}$$

The model just described fits a prescribed free-field pressure history at the standoff point in such a way that surface cutoff effects appear to the structure as emanating from an image source. Because the model is complete, it also provides the free-field fluid-particle-velocity information required for DAA calculations. The usefulness of the model has been demonstrated from the results of free-field tests specifically designed to produce both pressure and fluid-particle-velocity data [18].

2.7 USA-DAA$_2$ IMPLEMENTATION

The Improved Doubly Asymptotic Approximation [DAA$_2$] can be written as [4]

$$\begin{gathered} \underset{\sim}{M}_f \ddot{\underline{p}}_S + \rho c \underset{\sim}{A}_f \dot{\underline{p}}_S + \rho c \underset{\sim}{\Omega}_f \underset{\sim}{A}_f \underline{p}_S = \\ \rho c \left[\underset{\sim}{M}_f(\underset{\sim}{G}^T \dddot{\underline{x}} - \ddot{\underline{u}}_I) \underset{\sim}{\Omega}_f M_f(G^T \ddot{\underline{x}} - \dot{\underline{u}}_I)\right] \end{gathered} \tag{2.24}$$

where

$$\Omega_f = \eta \rho c A_f M_F^{-1} \tag{2.25}$$

All vector and matrix quantities in the above are related to the same finite element wet-surface fluid mesh as that used for the lowest order DAA (DAA_1) described in Section 2.2.

Note that DAA_2 is a second-order equation, whereas DAA_1 is a first-order equation. In addition, DAA_2 includes a new scalar parameter η that appears in (2.25). It can be established from physical considerations [4], that η must be bounded as

$$0 \leq \eta \leq 1 \tag{2.26}$$

A precise choice of η is apparently not predicated by any fundamental principle. Hence it must be regarded at this time as a factor which may be adjusted to achieve optimum accuracy for a particular problem. In [4], it is observed that η = 1 leads to the best accuracy for a spherical shell.

In order to implement DAA_2 (2.24) is first integrated once in time and multiplied through by $A_f M_f^{-1}$. Equation (2.25) is then substituted into the result and a new variable, the scattered pressure integral q_S, is defined by

$$q_S = \overset{*}{p}_S \tag{2.27}$$

where an asterisk denotes temporal integration. The result is

$$\begin{aligned} A_f \ddot{q}_S + \rho c D_{f1} \dot{q}_S + \eta \rho^2 c^2 D_{f2} q_S &= \\ \rho c A_f (G^T \ddot{x} - \dot{u}_I) + \eta \rho^2 c^2 D_{f1} (G^T \dot{x} - u_I) \end{aligned} \tag{2.28}$$

where

$$D_{f2} = A_f M_f^{-1} A_f M_f^{-1} A_f \tag{2.29}$$

It is noted that (2.28) is symmetric and that $\tilde{D}_{f1}$ has already been defined following (2.6).

To avoid shock-wave singularities in $\dot{\underline{u}}_I$, the relation for a spherical shock is used as

$$\rho c \dot{\underline{u}}_I = \tilde{\Gamma} (\dot{\underline{p}}_I + c \tilde{R}^{-1} \underline{p}_I) \tag{2.30}$$

while the modified pressure-integral vector is defined as

$$\underline{q}_M = \underline{q}_S + \tilde{\Gamma} \overset{*}{\underline{p}}_I \tag{2.31}$$

Substitution of (2.30, (2.31) into (2.28) then gives

$$\begin{aligned} &\tilde{A}_f \ddot{\underline{q}}_M + \rho c \tilde{D}_{f1} \dot{\underline{q}}_M + \eta \rho^2 c^2 \tilde{D}_{f2} \underline{q}_M = \\ &\rho c \tilde{A}_f \tilde{G}^T \ddot{\underline{x}} + \eta \rho^2 c^2 \tilde{D}_{f1} \tilde{G}^T \dot{\underline{x}} + c [(1-\eta) \rho \tilde{D}_{f1} - \tilde{A}_f \tilde{R}^{-1}] \tilde{\Gamma} \underline{p}_I \\ &+ \eta \rho^2 c^2 (\tilde{D}_{f2} - \frac{1}{\rho} \tilde{D}_{f1} \tilde{R}^{-1}) \Gamma \overset{*}{\underline{p}}_I \end{aligned} \tag{2.32}$$

where the identity

$$\tilde{R}^{-1} \tilde{\Gamma} = \tilde{\Gamma} \tilde{R}^{-1} \tag{2.33}$$

has been used in (2.32), as both matrices are diagonal. Associated with (2.32) is the structural equation of motion

$$\tilde{M}_s \ddot{\underline{x}} + \tilde{C}_s \dot{x} + \tilde{K}_s x = - \tilde{G} \tilde{A}_f [\dot{q}_M + (\tilde{I} - \tilde{\Gamma}) \underline{p}_I] \tag{2.34}$$

Equations (2.32) and (2.34) define the DAA_2-modified interaction equations that are solved according to the staggered solution strategy; hence an examination of stability must be conducted. It has been shown that the step-by-step integration of (2.32) and (2.34) is conditionally stable; however, no systematic study of stability has yet been undertaken. In view of the fact that unconditional stability was achieved for USA-DAA_1 by augmentation, and that (2.24) is essentially the DAA_1 with a correction term, augmentation of (2.32) was carried out in the same manner as that used for DAA_1.

Accordingly, (2.34) is first solved for $\ddot{\underline{x}}$ and substituted into (2.32) to give

$$
\begin{aligned}
&\underset{\sim}{A}_f \ddot{\underline{q}}_M + \rho c (\underset{\sim}{D}_{f1} + \underset{\sim}{D}_s) \dot{\underline{q}}_M + \eta \rho^2 c^2 \underset{\sim}{D}_{f2} \underline{q}_m = \\
&\quad - \rho c \underset{\sim}{A}_f \underset{\sim}{G}^T \underset{\sim}{M}_s^{-1} (\underset{\sim}{C}_s \dot{\underline{x}} + \underset{\sim}{K}_s \underline{x}) + \eta \rho^2 c^2 \underset{\sim}{D}_{f1} \underset{\sim}{G}^T \dot{\underline{x}} \\
&\quad - \rho c \{\underset{\sim}{D}_s - [\underset{\sim}{D}_s + (1-\eta) \underset{\sim}{D}_{f1} - \frac{1}{\rho} \underset{\sim}{A}_f \underset{\sim}{R}^{-1}] \underset{\sim}{\Gamma}\} \underline{p}_I \\
&\quad + \eta \rho^2 c^2 (\underset{\sim}{D}_{f2} - \frac{1}{\rho} \underset{\sim}{D}_{f1} \underset{\sim}{R}^{-1}) \underset{\sim}{\Gamma} \overset{*}{\underline{p}}_I
\end{aligned}
\qquad (2.35)
$$

where $\underset{\sim}{D}_s$ has already been defined following (2.6).

Equations (2.34) and (2.35) are the DAA_2-modified, augmented interaction equations that have been implemented in the USA Code.

SECTION III

ORGANIZATION

The USA Code has been written in standard FORTRAN IV for use on both Univac and CDC computers. Machine dependency has been isolated in one utility program described below. Program modularity has been strictly enforced, with communication between computational modules controlled by means of a data management system.

The basic structure of the code is shown in Fig. 3-1. The structural preprocessor is a separate code selected by the user to provide the computational model for the structure. The skyline utility merely reformats $\underset{\sim}{M}_s$ and $\underset{\sim}{K}_s$ as provided by the structural preprocessor for processing by the USA Code (recall that $\underset{\sim}{C}_s$ is taken as zero). The fluid mass preprocessor forms $\underset{\sim}{A}_f$, $\underset{\sim}{M}_f$, $\underset{\sim}{D}_{f1}$, $\underset{\sim}{D}_{f2}$ and $\underset{\sim}{G}$ using a virtual memory simulator for out-of-core processing, while the matrix augmentation preprocessor forms $\underset{\sim}{D}_s$ and $\underset{\sim}{A}_f\underset{\sim}{G}^T\underset{\sim}{M}_s^{-1}$ [see (2.9)]. The main processor is the time integrator, which forms $\underset{\sim}{\Gamma}$ and $\underset{\sim}{H}$ and then solves (2.9) in step-by-step fashion using the staggered solution procedure. The response postprocessor provides tabular and graphic output for the computed kinematic responses as well as pseudo-velocity shock spectra. Finally, the data manager controls the flow of data between processors. More detailed descriptions of the various program components follow, while information required for utilization of the code is contained in Appendices A through D.

3.1 THE DATA MANAGER DMGASP

DMGASP is a self-contained utility module that functions as a manager of auxiliary storage and as the focal point for all block input/output activities [19]. Constituting the lowest level of the NOSTRA Data Management System [20], it carries out the direct transfer of data blocks between core and peripheral storage. (The terminology "direct transfer" is used here to denote unformatted and unbuffered data transmission.) The basic auxiliary storage management operations embodied in DMGASP are

- Activate storage device
- Position device
- Read data block from device
- Write data block on device
- Deactivate device

In the USA Code, DMGASP is operated as a stand-alone I/O package that receives directives directly from the master processors. Assembly language versions of DMGASP currently exist for UNIVAC 1100 EXEC-8, CDC SCOPE 3.4 (NOS/BE), and CDC NOS operating systems; hence the USA Code may be used only on these systems at this time.

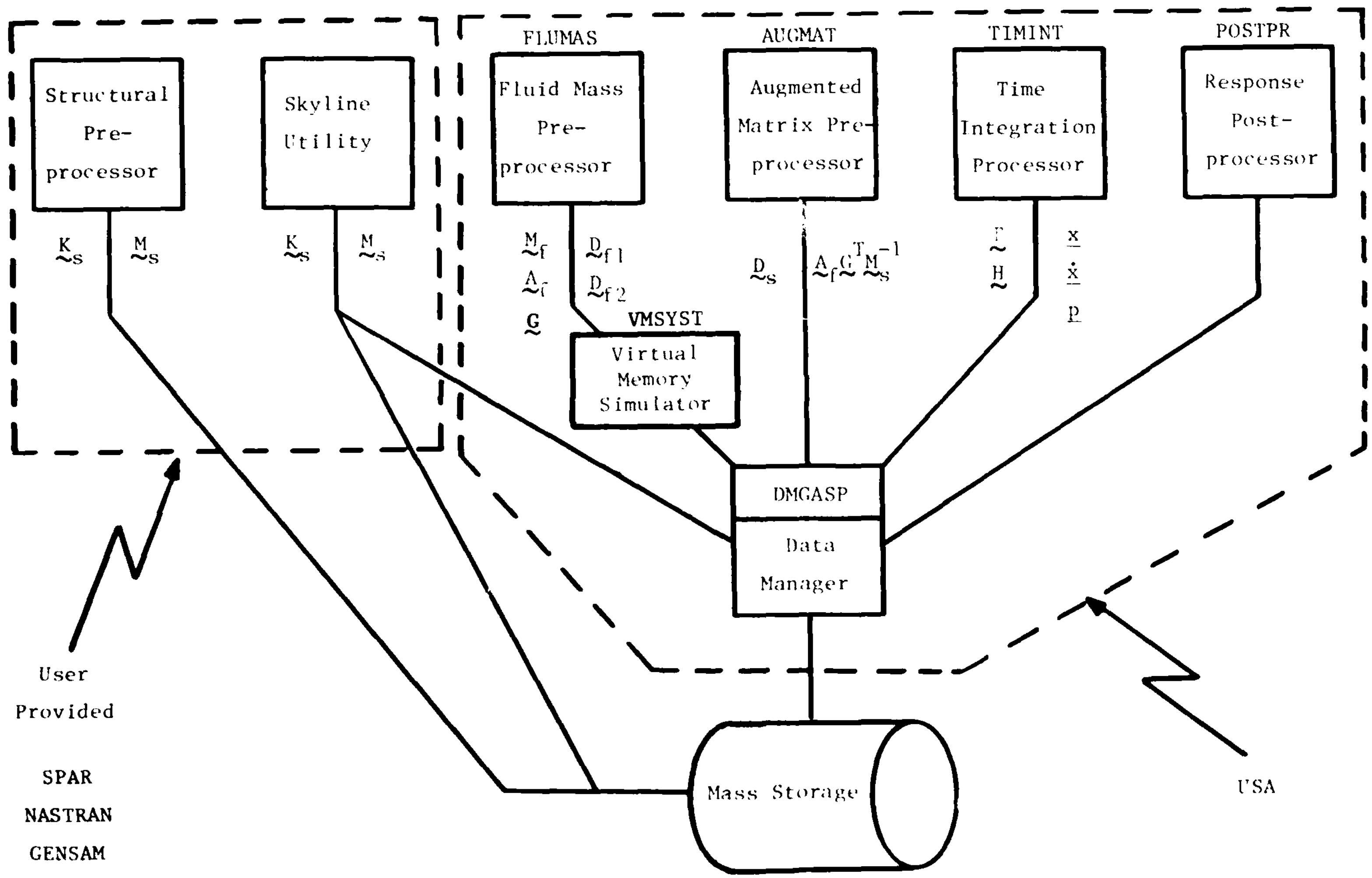

Figure 3-1. Organization of USA Code

3.2 THE VIRTUAL MEMORY SIMULATOR VMSYST

VMSYST is a virtual storage simulator for computers that are not built around a virtual memory system [21]. All data in the virtual system is partitioned into pages, which are blocks of consecutive data words of a fixed page size. Pages residing in core in the page buffer are called active pages. Inactive pages are resident in auxiliary storage only. In this utility the page and page buffer sizes can be conveniently adjusted to suit the application. Input and output to auxiliary storage is handled by DMGASP; otherwise VMSYST is written in transportable FORTRAN.

The primary advantage of a virtual memory system is the efficient processing of many small records such as columns or rows of large full matrices that can be treated as vectors. In essence VMSYST keeps track of whether a desired block of data is resident in core in the page buffer, or, has been moved to an external storage device by DMGASP. If it is not currently resident in the page buffer, VMSYST retrieves it and makes it available to the application program. This double movement of data is the major price paid for the benefits of the virtual system.

In USA, VMSYST is used for the out-of-core generation of the fluid mass matrix described in Section 3.5.

3.3 THE STRUCTURAL PREPROCESSOR

This is a user-provided code that assembles the structural mass and stiffness matrices and generates information that relates the internal and external descriptions of the structural DOF. Input typically includes

- Mesh geometry
  - Coordinate systems
  - Node locations
- Element definitions
  - Type
  - Connectivity
- Material properties
  - Mass density
  - Moduli
- Constraints
  - Symmetry conditions
  - Element external constraints
  - Element internal constraints

Fluid internal to the submerged structure must be included in the structural model. At this time, USA treats only diagonal mass matrices associated with a lumped mass representation of the structure, and only single precision matrices can be processed.

3.4 THE SKYLINE UTILITY

This preprocessor converts the structural mass and stiffness matrices generated by the structural preprocessor into the internal "skyline" format required by the USA time integration processor [22,23]. As there are a variety of ways to store large, sparse, symmetric matrices, virtually any structural preprocessor that is to be used with the USA Code will require a utility package to change the storage format. At this time, conversion utilities have been written for SPAR [24], NASTRAN [25] and GENSAM [26]. User instructions for constructing the skyline utility for other structural codes are given in Appendix E. As is noted there, USA now contains a set of utilities to facilitate this process.

Figure 3.1 shows 2 paths to mass storage from the skyline utility. The SPAR converter uses DMGASP for both input and output, whereas the NASTRAN converter uses unformatted buffered FORTRAN commands for input and DMGASP for output.

Constraints are also handled differently in these two utilities. NASTRAN provides a reduced stiffness matrix which already incorporates any prescribed constraints. SPAR does not; however, USA has the ability to apply constraints due to symmetry or attachment to ground during the time integration. Structural DOF that must be set to zero are flagged by the skyline utility [23].

3.5 THE FLUID MASS PREPROCESSOR FLUMAS

This code constructs the fluid mass matrix for a structure submerged in an infinite, inviscid, incompressible fluid by the boundary element technique [14]. In addition, FLUMAS can form the mass matrix for a body in the vicinity of a fluid free surface through the use of imaging techniques. Out-of-core processing is facilitated by use of the virtual memory system VMSYST so that core size is not a limitation on the number of fluid DOF. The code also generates fluid mesh data and a set of transformation coefficients relating the structural and fluid DOF. The computation of these coefficients is based upon the use of centroidal nodes for the fluid elements and the assumption of a bilinear variation of displacement over the surface of each structural element. This assures that the description of the fluid pressure forces in the two mesh systems is statically equivalent without inducing moments at the structural nodes. Finally, the code generates the symmetric matrices $\underset{\sim}{D}_{f1}$ and $\underset{\sim}{D}_{f2}$ that appear in the computational form of the DAA_1 and DAA_2 equations which involve the inverse of the fluid mass matrix.

FLUMAS contains a refined formulation for the fluid mass matrix that includes the primary effects of element curvature. In addition, it has the capability to treat structures containing both general geometry and arbitrary axis, multi-branch, multi-harmonic surface-of-revolution components, as described in [10]. The code can also efficiently construct the fluid mass matrix for a body with one or two planes of symmetry by using a mesh which covers 1/2 or 1/4 of the surface. Symmetric or anti-symmetric fluid motions can then be imposed on the portions of the surface not covered by the mesh. Two-dimensional "plane-strain" behavior of long cylinders can also be simulated. The code contains an automatic mesh generator for cylindrical surfaces and an improved error exit control that facilitates fluid mesh debugging. Finally, a useful diagnostic tool in the code is the capability to solve the fluid-boundary-mode problem $\underset{\sim}{M}_f \underline{u} = \lambda \underset{\sim}{A}_f \underline{u}$ [14].

Typical input data for this processor includes

- Mesh geometry
  - Fluid Wet-Surface Mesh
  - Structure Wet-Surface Mesh
- Element definitions
  - General curved surface
  - Surface of revolution
- Material property
  - Mass density
  - DAA_2 parameter
- Constraints
  - Location of free surface
  - Half model
  - Quarter model
  - Long cylinder
  - Node reassignment in fluid-structure transformation

A detailed description of the required input data is given in Appendix A.

3.6 THE AUGMENTED MATRIX PREPROCESSOR AUGMAT

This processor accepts data from the structural and fluid analyzers to construct the specific matrices required for solution of the augmented Eqs. (2.9) or (2.34)/(2.35). The output of this code includes not only the required matrices in skyline form, but also a distillation of the output from both the structural and fluid processors. This has been done so that only one permanent file need be referenced as input to the time integrator; this results in improved data handling and core usage. In contrast to earlier versions of USA, AUGMAT does not form the fluid matrices $\underset{\sim}{D}_{f1}$ and $\underset{\sim}{D}_{f2}$ but rather puts

them in the skyline format required by SKYPUL. $\underset{\sim}{D}_{f1}$ and $\underset{\sim}{D}_{f2}$ are now formed only in FLUMAS. The structural stiffness matrix can also be displayed in AUGMAT for checkout purposes. Input to this code involves the following information

- Mass matrices
  - Fluid
  - Structure
- Structural DOF correspondence table
  - External and internal node descriptions
  - Factorization order
  - DOF reduction due to constraints
- Fluid mesh geometry
  - Global coordinates of fluid nodes
  - Direction cosines for nodal surface normals
  - Areas of fluid elements
- Fluid/structure DOF transformation coefficients
- Fluid material properties
  - DAA_2 parameter
- Constraints
  - Half model
  - Quarter model

Although this constitutes a substantial amount of information, almost all of it is retrieved from permanent data files. A detailed discussion of the required input data is contained in Appendix B.

3.7 THE TIME INTEGRATION PROCESSOR TIMINT

This main processor constitutes an implementation of the unconditionally stable staggered solution technique developed in [9] for DAA_1. The primary output is a set of permanent data files that contain nodal values for structural displacement, structural velocity and wet-surface pressure at every time step. In addition, parallel files are created that retain restart information at time intervals dictated by the user. The code has a variable time step capability and can treat a spherical incident wave of arbitrary pressure profile and source location. Exponentially decaying waves can also be treated by providing magnitude and decay information. In addition, incident wave pressure and particle velocity are tabulated and displayed with a "printer-plot" package. If the body is in the vicinity of a free surface, unloading due to reflection of the incident

wave from the surface is included and the effects of bulk cavitation on the free field pressure history are approximately treated. Finally, selected response histories can be listed and then displayed for immediate examination using the "printer-plot" graphics package embedded both in TIMINT and in POSTPR (see Sect. 3.8).

The computational strategy for the staggered solution procedure is embodied in the following eight steps, assuming the solution is known at time t:

(1) Estimate the unknown structural restoring force $\underset{\sim}{K}_s \underline{x}$ at $t + \Delta t$ from the extrapolation of current and past values

(2) Transform this extrapolation into fluid node values and form the right-hand side of the fluid equation, which also involves the known incident pressure at $t + \Delta t$

(3) Solve the fluid equation and obtain a preliminary estimate of the total pressure vector at $t + \Delta t$

(4) Transform fluid pressures into structural nodal forces

(5) Solve the structural equation for the displacement and velocity vectors at $t + \Delta t$

(6) Transform the computed structural restoring forces at $t + \Delta t$ into fluid node values and reform the right hand side of the fluid equation

(7) Re-solve the fluid equation and obtain refined values for the total pressures at $t + \Delta t$

(8) Save system responses

Steps 1, 3, and 5 constitute the basic staggered solution technique, while Steps 2 and 4 are required because of the difference between the fluid and structural surface meshes. The iteration on the fluid solution reflected in Steps 6 and 7 has been added to enhance accuracy. Inasmuch as the computation time is overwhelmed by the structural solution requirements, this requires only a small increase in total run time. The use of a three-point extrapolation method in Step 1 also improves accuracy, as discussed in [9].

Implicit integration algorithms have been used for both the fluid and structural equations. The former is treated with the 3-step Park method [27] while the latter is treated with the "JO" implementation of the trapezoidal rule [28].

Typical input to this processor includes

- Incident wave characteristics

Location of source

Location of standoff

Pressure profile

Linear interpolation

Cubic spline fit

Exponentially decaying wave

- Time step information

  Start and finish times

  Time increment values

- Restart data

- Display directives

  Displacements

  Velocities

  Pressures

Detailed user information concerning TIMINT is given in Appendix C.

3.8 THE RESPONSE POSTPROCESSOR POSTPR

This utility is responsible for the listing and "printer-plot" as well as "vector-plot" graphic display of selected system responses and pseudo-velocity shock spectra. Output files containing the structural displacement field at user-specified instants in time may also be created from the response history files to provide "snapshots" of the deformed structure. Some of the same capabilities are also embedded in the TIMINT processor for immediate selective scanning of the output. POSTPR, however, is used for more detailed examination of the results at a later time. As a complete display of all structural and fluid DOF histories for even a moderate size problem could run into thousands of pages of output, care must be exercised in the selection of data to be displayed. Usage of this code is discussed in Appendix D.

SECTION IV

EXAMPLE PROBLEMS

This section presents results generated by the USA Code for three idealized underwater and free surface shock problems. The structure studied in the first problem is a hollow circular beam of finite length, while that involved in the second and third problems is an infinite, circular cylindrical shell. In all cases, the structure is excited by a transverse, plane step-wave of unit incident pressure and material properties are used that correspond to a steel shell immersed in water. The input data are normalized so that the density and speed of sound for the fluid both equal unity; hence, the density, Young's modulus, and Poisson's ratio for the structural material are taken as 7.85, 98.125, and 0.3, respectively. The radius and wall thickness of the beam and the cylinder are 1 and 0.01, respectively, while the length of the beam is 9. In order to assess the accuracy of the computational results, selected response histories are compared with those obtained by other methods.

4.1 CIRCULAR BEAM

The response variable of primary interest in this problem is the late-time asymptotic translational velocity V_∞ of the structure. An analytical expression for this quantity may be obtained from (2.5) by taking $\dot{\underline{x}} = \underline{\gamma}_{Ps}\, v(t)$, where $\underline{\gamma}_{Ps}$ is the vector of direction cosines relating the translational motions of the structural nodes and the direction of propagation of the plane incident wave. (The elements of $\underline{\gamma}_{Ps}$ that pertain to the rotational DOF are, of course, zero.) The introduction of this relation into the first of 2.5, followed by premultiplication of the resulting equation by $\underline{\gamma}_{Ps}^T$, then yields

$$m_s \dot{v} = - \underline{\gamma}_S^T \underset{\sim}{G}\, \underset{\sim}{A}_f (\underline{p}_I + \underline{p}_S) \tag{4.1}$$

where $m_s = \underline{\gamma}_{Ps}^T \underset{\sim}{M}_f \underline{\gamma}_{Ps}$; this follows from the fact that $\underset{\sim}{C}_s \underline{\gamma}_{Ps} = \underset{\sim}{K}_s \underline{\gamma}_{Ps} = \underline{0}$.

After the wave front of the plane step-wave has enveloped the structure, i.e., for $t > t_e$,

$$\begin{aligned} \underline{p}_I &= \rho\, c\, U_I\, \underline{1} \\ \overset{*}{\underline{p}}_I &= \rho\, c\, U_I (t\underline{1} - \underline{t}_A) \\ \underline{u}_I &= U_I \underline{\gamma}_P \end{aligned} \tag{4.2}$$

where U_I is the fluid particle velocity characterizing the step-wave, $\underline{1}$ is the unity vector, the asterisk denotes the temporal integral of the quantity beneath it, $\underline{t}_A$ is the vector of incident-wave arrival times for the fluid surface elements, and $\underline{\gamma}_P$ is the vector of direction cosines relating the normals of the fluid elements to propagation vector of

the plane incident wave. In addition, $|\dot{p}_S| << |p_S|$ for late-time motions (see Section 2.2), so that the second of (2.5) becomes

$$p_S = A_f^{-1} M_f (G^T \gamma_{Ps} \dot{v} - \dot{u}_I), \quad t>>t_e \tag{4.3}$$

The introduction of this relation into (4.1) then yields

$$(m_s + m_a)\dot{v} = -\gamma_{Ps}^T G A_f p_I + \gamma_{Ps}^T G M_f \dot{u}_I, \quad t>>t_e \tag{4.4}$$

where the added mass $m_a = \gamma_{Ps}^T G M_f G^T \gamma_{Ps}$. But, from (4.4), $G^T \gamma_{Ps} = \gamma_P$, so that m_a is also given as $m_a = \gamma_P^T M_f \gamma_P$.

With $G^T \gamma_{Ps} = \gamma_P$, the first of (4.2) yields $\gamma_{Ps}^T G A_f p_I = \rho c U_I \gamma_P^T A_f 1 = 0$, inasmuch as the wet surface of the structure is closed. Hence, the right side of (4.4) vanishes for $t > t_e$, which gives the expected result $\dot{v} = 0$. This prompts the use of integrated forms of (4.1) and (4.3) (with quiescent initial conditions), which yields, instead of (4.4),

$$(m_s + m_a) v = -\gamma_P^T A_f \overset{*}{p}_I + \gamma_P^T M_f u_I, \quad t>>t_e \tag{4.5}$$

The introduction of the second and third of (4.2) into this equation then provides the desired expression for late-time asymptotic translational velocity

$$V_\infty = \frac{m_d + m_a}{m_s + m_a} U_I \tag{4.6}$$

where the structure's displaced mass m_d may be shown to be expressible as $m_d = \rho c \gamma_P^T A_f (t1 - t_A)$. Note that (4.6) is a general result, applicable to any wet-surface geometry.

Two different uniform mesh geometries were used to study the circular beam. Ten- and twenty-node models were constructed with beam elements provided by the structural analyzer SPAR [29]. The corresponding fluid models contained 11 and 21 elements of equal size, with 12 and 24 circumferential integration points (see [10]). In each case there was a fluid element on each end to account for axial motion while all the rest were evenly distributed along the length. For the beam considered, $m_s = 4.439$ and $m_d = 28.274$; with m_a determined as $m_a = \gamma^T M_f \gamma$, mesh geometry has a small effect on the value calculated for V_∞. It was found that $m_a = 24.509$ for the coarse mesh and $m_a = 24.332$ for the fine mesh, which yield $V_\infty = 1.823$ and $V_\infty = 1.828$, respectively.

In the response calculations, a constant time step of 0.1 (20 steps per envelopment period) was used for both models; the results are shown in Figures 4-1 and 4-2. Velocities at the ends of the beam are higher than those at the center because the three-dimensional flow field at the ends offers less resistance to the plane wave excitation than the two-dimensional flow field at the center. It is noted that the responses of both

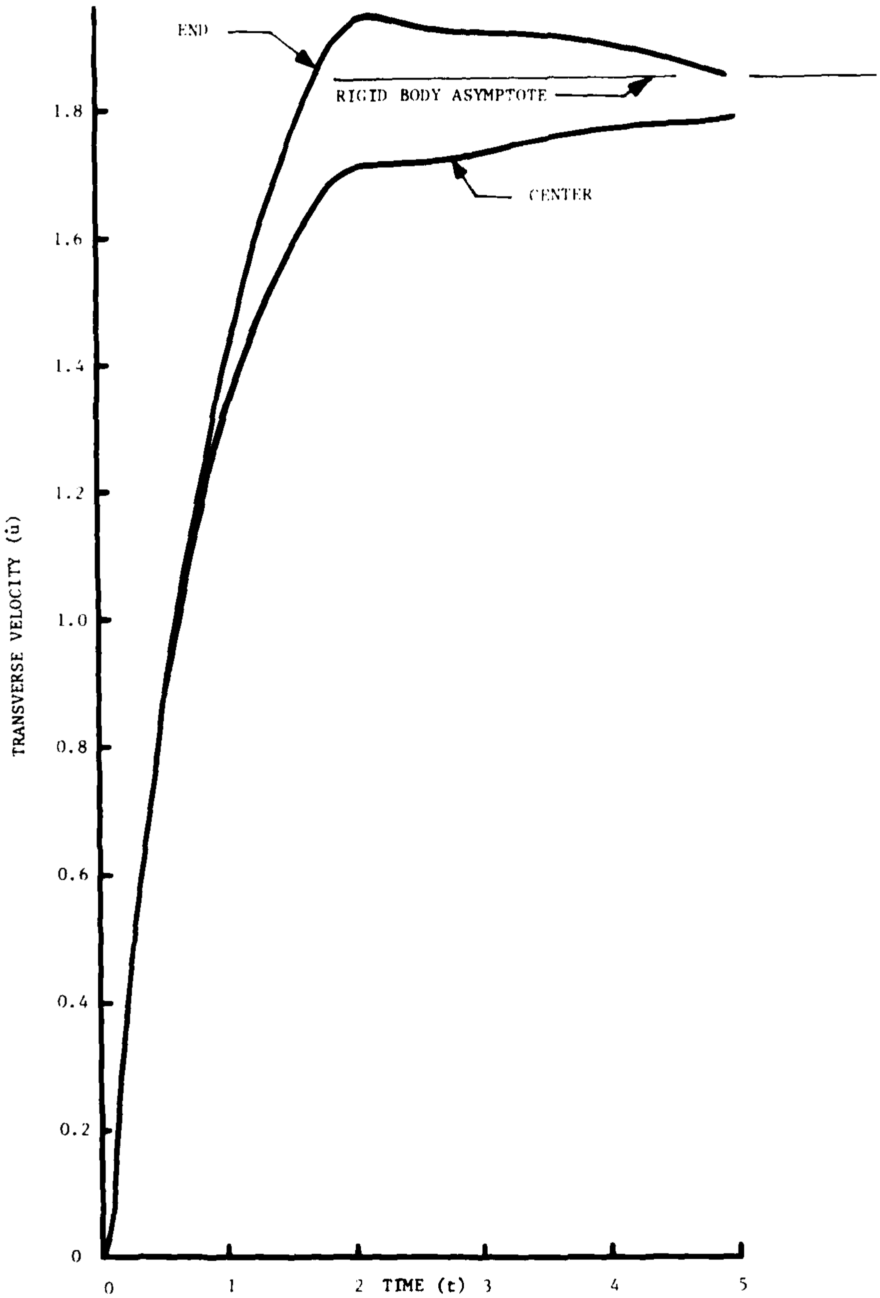

Figure 4-1 Transverse Velocity of Finite Beam, Coarse Mesh

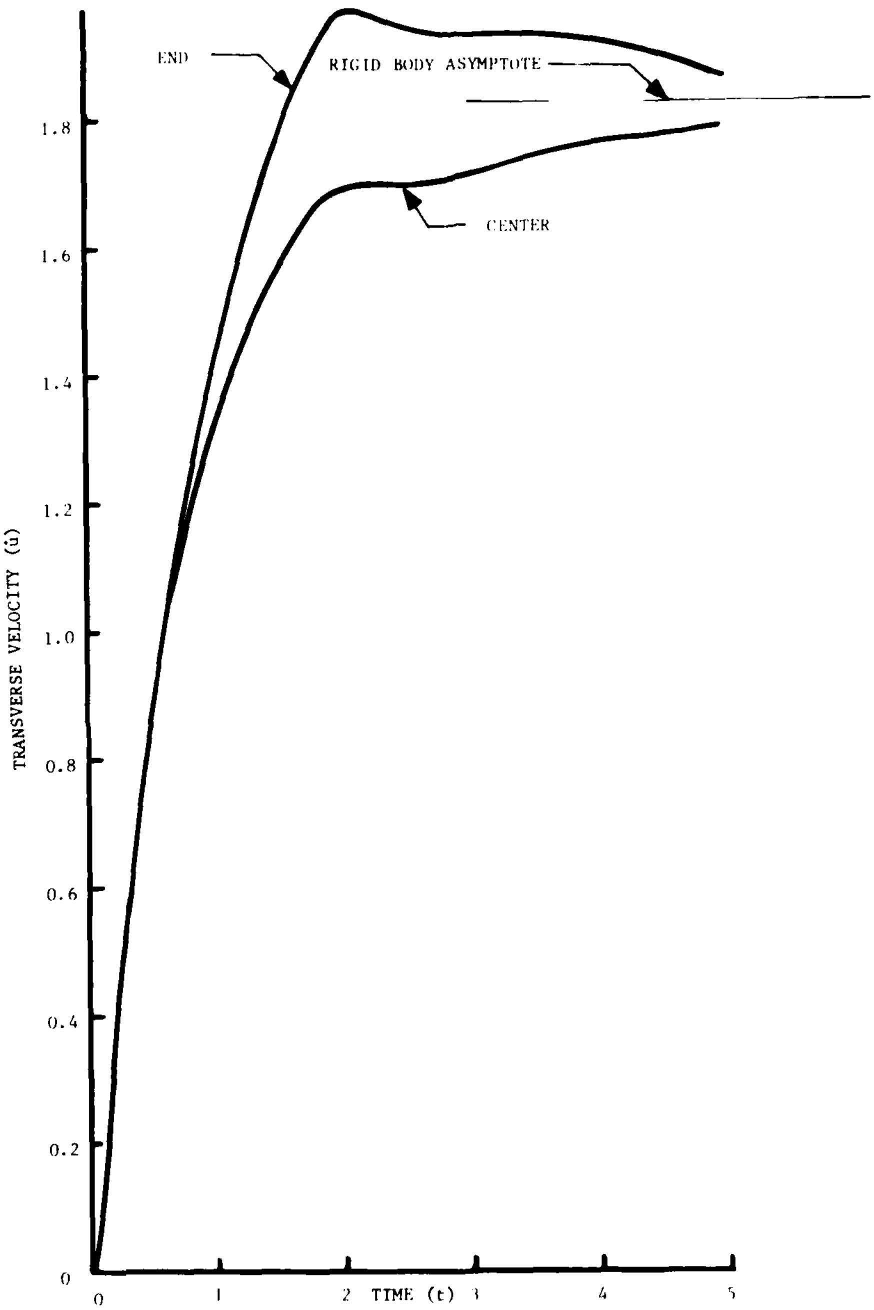

Figure 4-2 Transverse Velocity of Finite Beam, Halved Mesh

models are similar although those for the finer mesh appear to tend to the rigid body asymptotic velocity more precisely.

The USA(3) Code can also treat the bar response of the circular beam and to illustrate this capability the axial displacement response of the end under the side-on loading is shown in Figure 4-3 for the coarse mesh problem only. The expected static displacement is easily determined from the physical characteristics of the problem to be 2.293 and it is noted that the computational result is settling down to that value. However, the time required for this to happen is much greater than the time for the beam to achieve the expected transverse velocity shown in Figure 4-1. This is because the axial frequency of the beam is low due to the entrained fluid. The natural frequency of this system can easily be found by Rayleigh's method as follows.

Under a harmonic excitation $u = Bx \sin \omega t$ the maximum potential energy U_{max} and the maximum kinetic energy T_{max} can be shown to be

$$
\begin{aligned}
U_{max} &= \frac{1}{2} B^2 A E \ell \\
T_{max} &= \frac{1}{24} B^2 A \rho \ell^3 \omega^2 + \frac{1}{8} B^2 m_f \ell^2 \omega^2
\end{aligned}
\tag{4.7}
$$

where u is the axial displacement measured from one end, x is the axial coordinate, ω is the circular frequency, t is time, A is the cross-sectional area, E is Young's modulus, ℓ is the bar/beam length and m_f is the fluid added mass for the axial breathing mode of the bar/beam. Equating U_{max} to T_{max} then gives a value for the period p_{wet} as

$$p_{wet} = p_{dry} \sqrt{1 + 3\, m_f/m_s}$$

where

$$
\begin{aligned}
p_{dry} &= \pi \ell \sqrt{\rho/3E} \\
m_s &= \rho A \ell
\end{aligned}
\tag{4.8}
$$

For the problem at hand $p_{dry} = 4.617$, $m_f = 4.913$, and $m_s = 4.493$ which gives $p_{wet} = 9.597$, about twice as long as the dry period. It is noted from the peak-to-peak times shown in Figure 4-3 that the computational result is in excellent agreement.

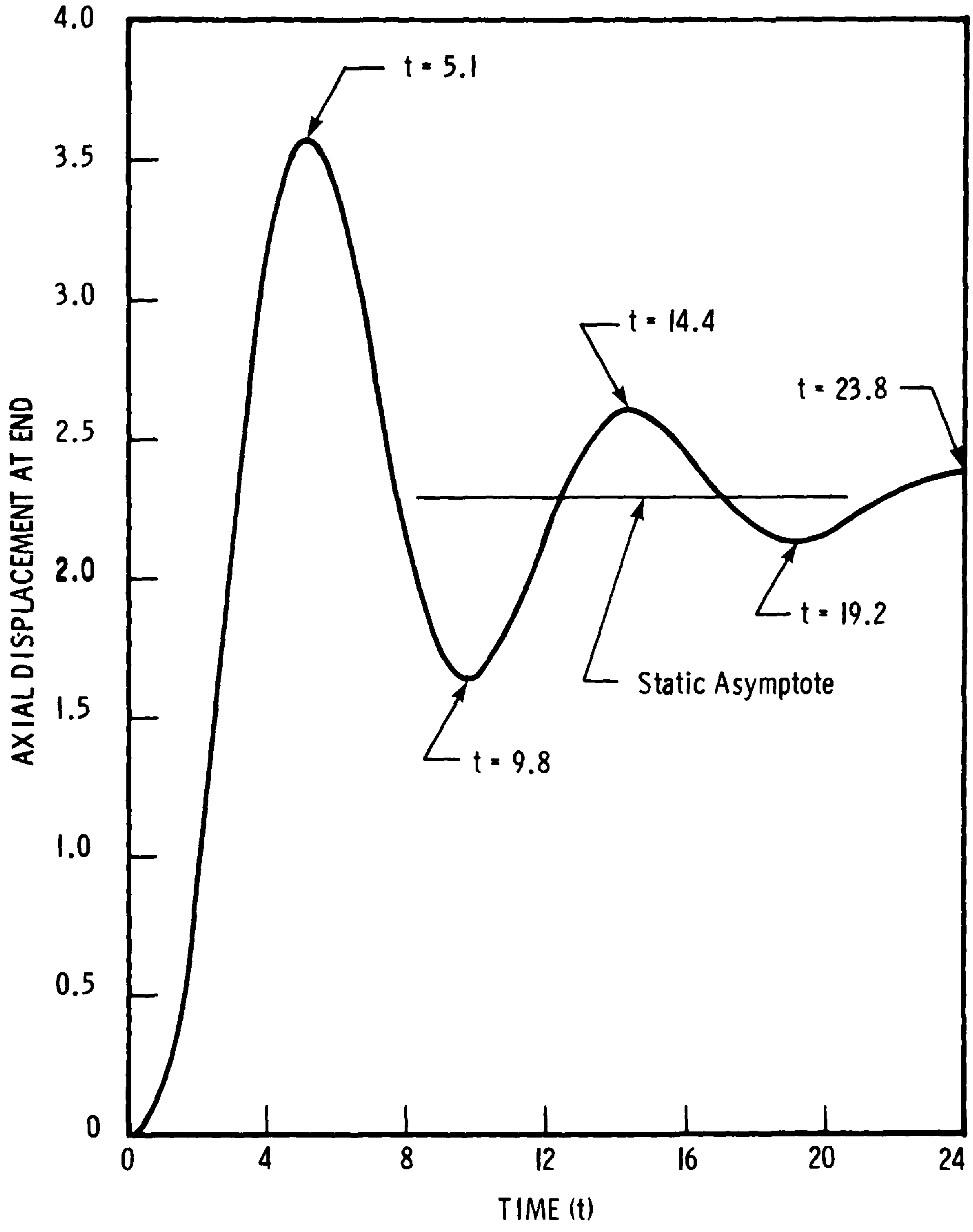

Figure 4-3 Axial Displacement at End of Finite Beam, Coarse Mesh

4.2 SUBMERGED INFINITE CYLINDRICAL SHELL

For this problem, a 72-node, 36-element SPAR model with a uniform circumferential mesh was constructed. The length of the cylindrical shell equalled the circumferential dimension of the square plate elements used for the model; hence the shell was one element long. Kinematic constraints of zero axial displacement and no end rotation were enforced through the skyline utility, as described in Section 3.3. The fluid model consists of 36 equally-spaced elements around the circumference; the two-dimensional nature of the infinite shell geometry was simulated by exercising an option in the fluid preprocessor FLUMAS that adds fictitious elements in the axial direction.

Two-dimensional n=0, 1, and 2 modal response results were generated by circumferential Fourier decomposition of USA-generated responses. For comparison DAA analytical solutions were generated by the method described in [8] and [30]. The primary response variables of interest were radial displacement for n=0, radial and tangential velocity for n=1, and radial and tangential displacement for n=2. A time step of 0.025 was used up to t=1; for t between 1 and 2 this was increased 0.05, and for t greater than 2 a time step of 0.1 was used.

The USA and corresponding analytical results are shown, harmonic by harmonic, in Figures 4-4 through 4-8. In all cases the maximum errors made by USA fall into the range of 1 to 2%.

4.3 SEMI-SUBMERGED INFINITE CYLINDRICAL SHELL

Analytical solutions for the problem of a shock-wave-excited, infinite, circular cylindrical shell whose axis lies in the plane of the free surface of a semi-infinite acoustic medium may readily be obtained. The appropriate geometry for an imaging representation of this problem is shown in Figure 4-9. An earlier treatment is described in [31], where the stiffness of the shell is neglected and an approximate expression is obtained for the asymptotic value for vertical rigid-body translational velocity. In this subsection it is shown that both exact and approximate solutions for the infinite-fluid case may be used directly to obtain solutions for the case of a semi-infinite fluid, as follows.

The shell and fluid variables are first expanded in circumferential harmonics as

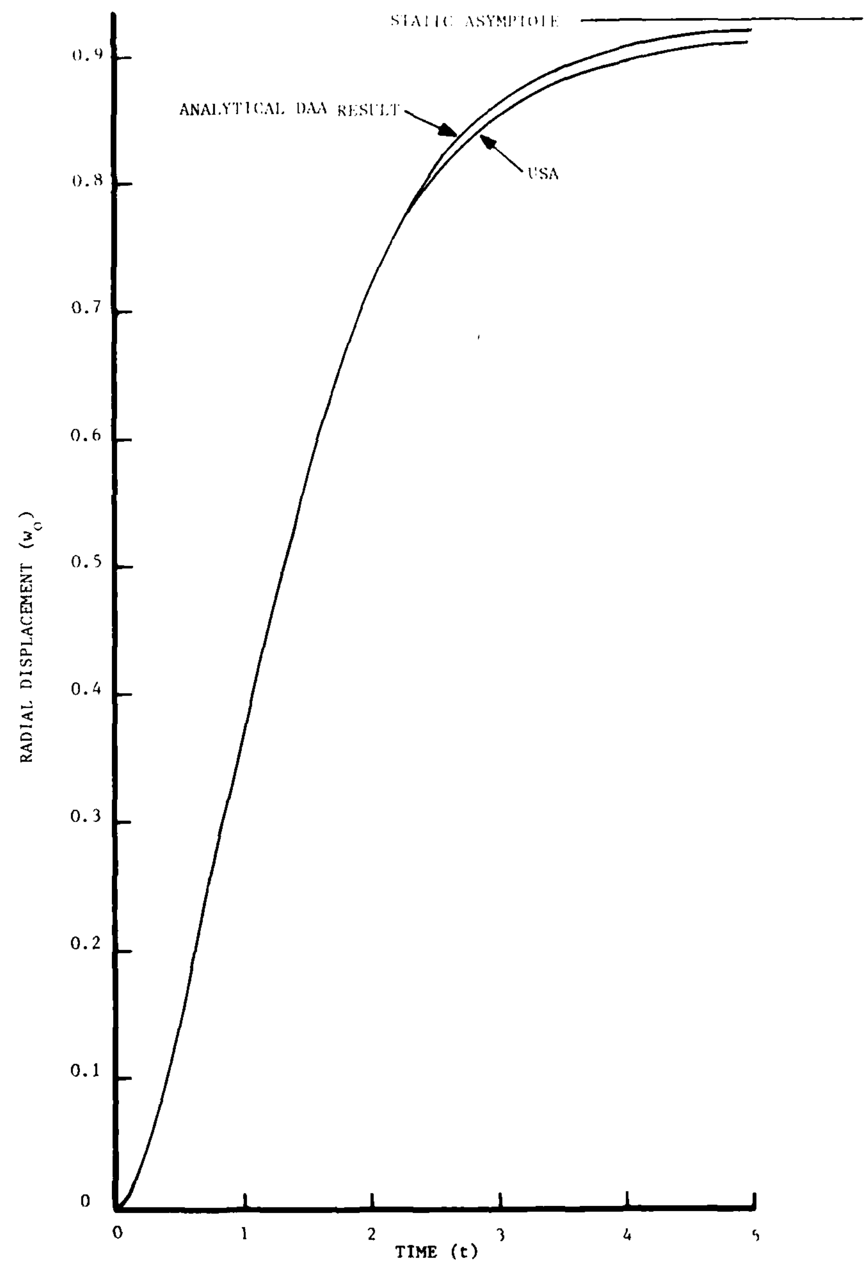

Figure 4-4 n=0 Radial Displacement of Infinite Cylinder in Infinite Fluid

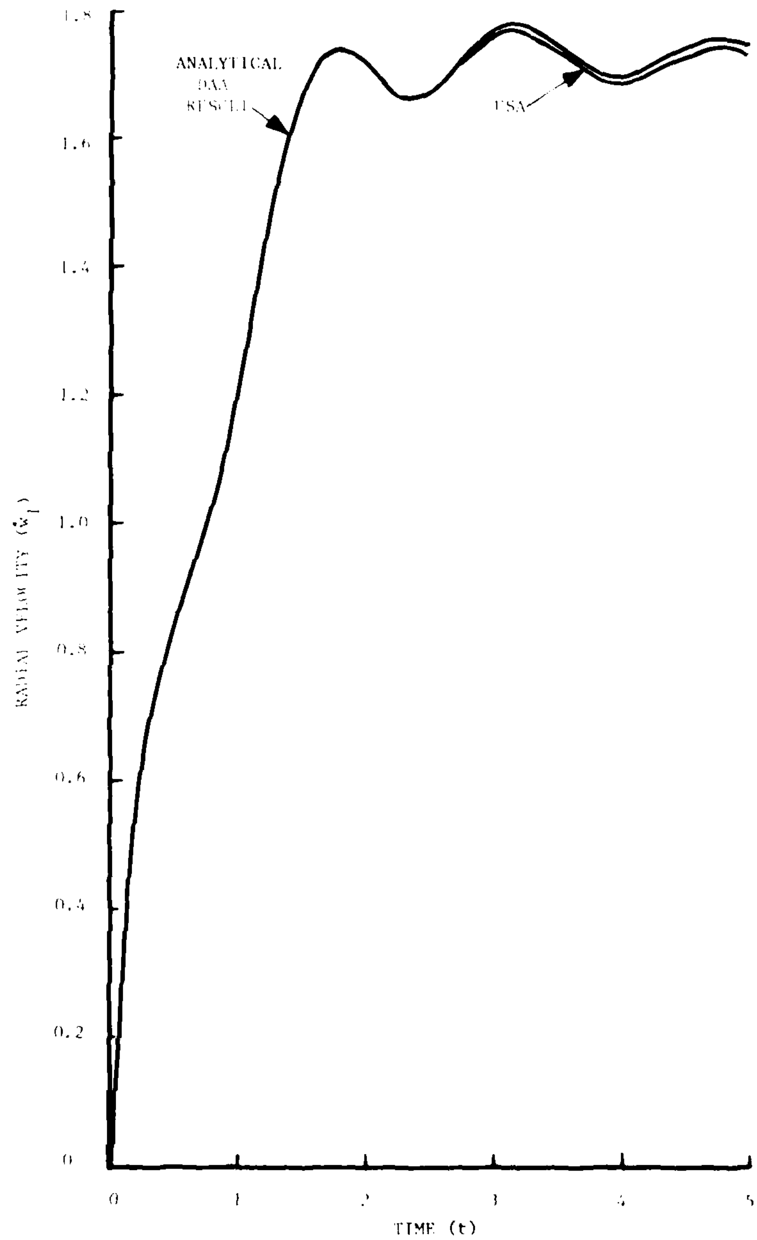

Figure 4-5 n=1 Radial Velocity of Infinite Cylinder in Infinite Fluid

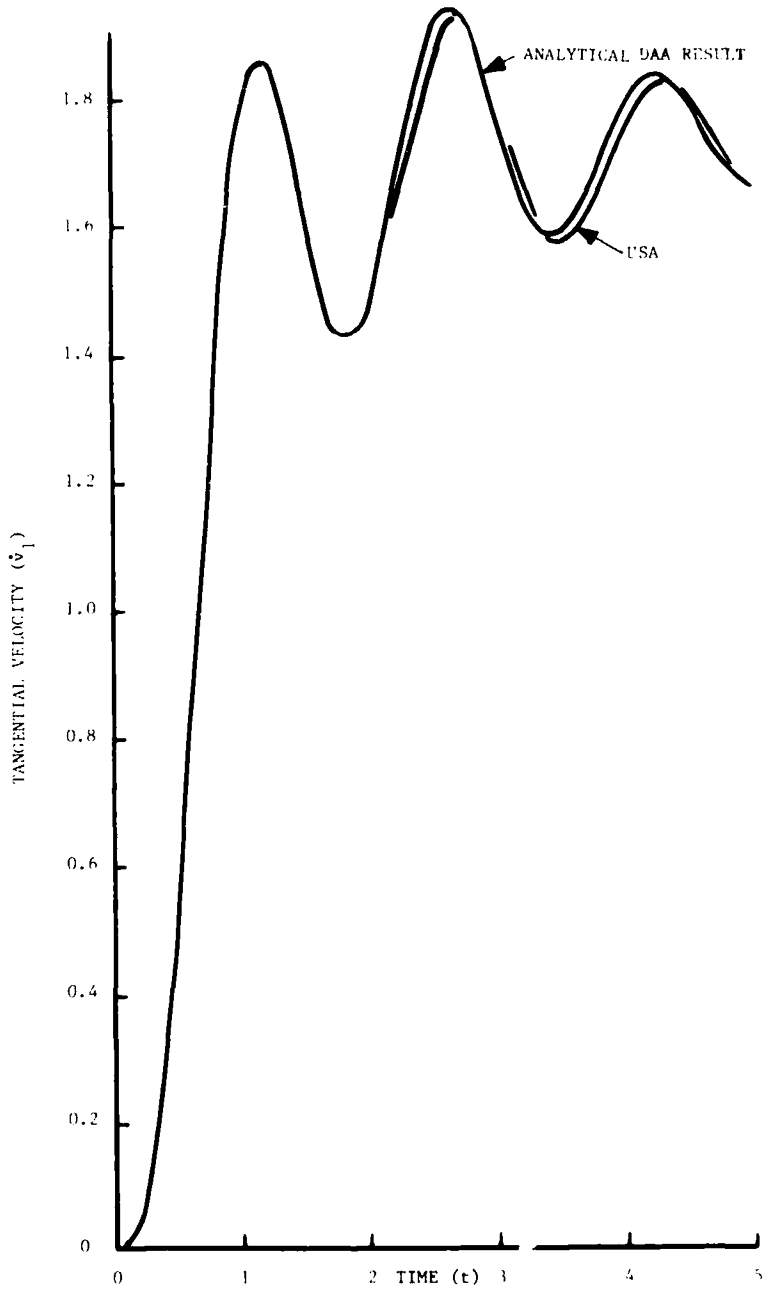

Figure 4-6 n=1 Tangential Velocity of Infinite Cylinder in Infinite Fluid

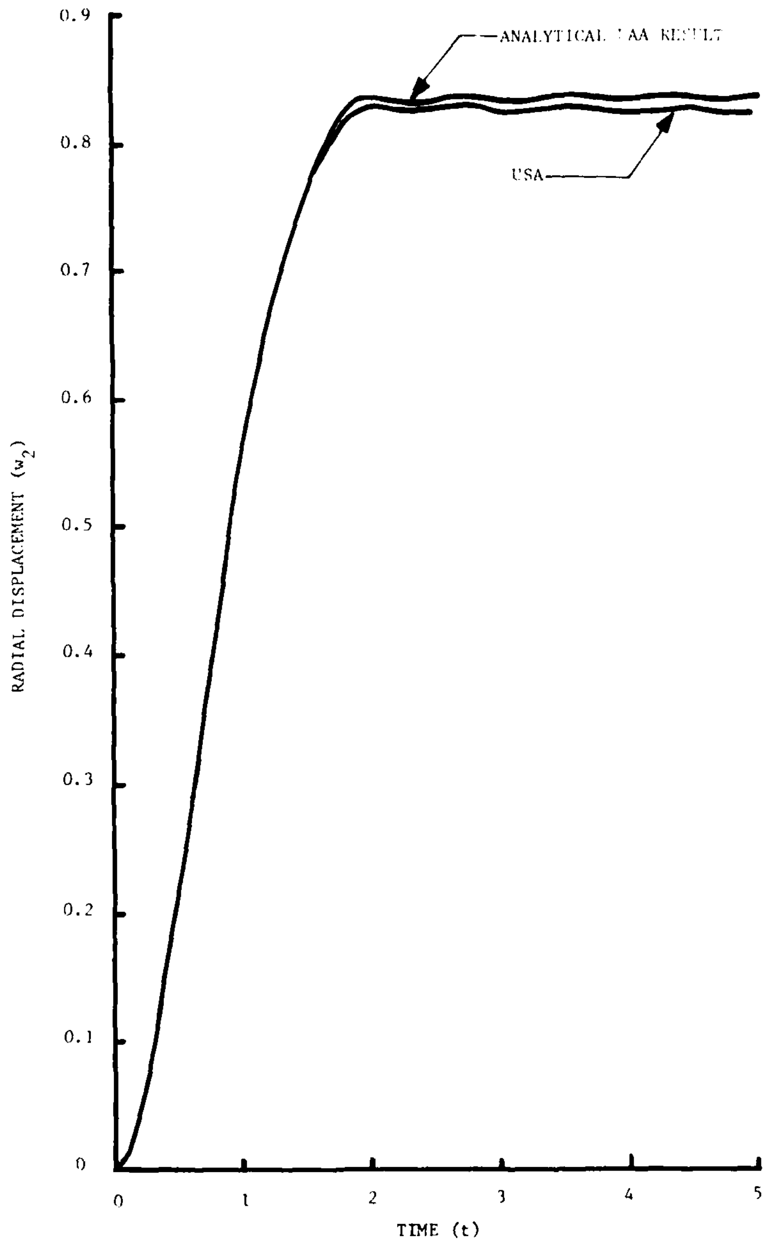

Figure 4-7 n=2 Radial Displacement of Infinite Cylinder in Infinite Fluid

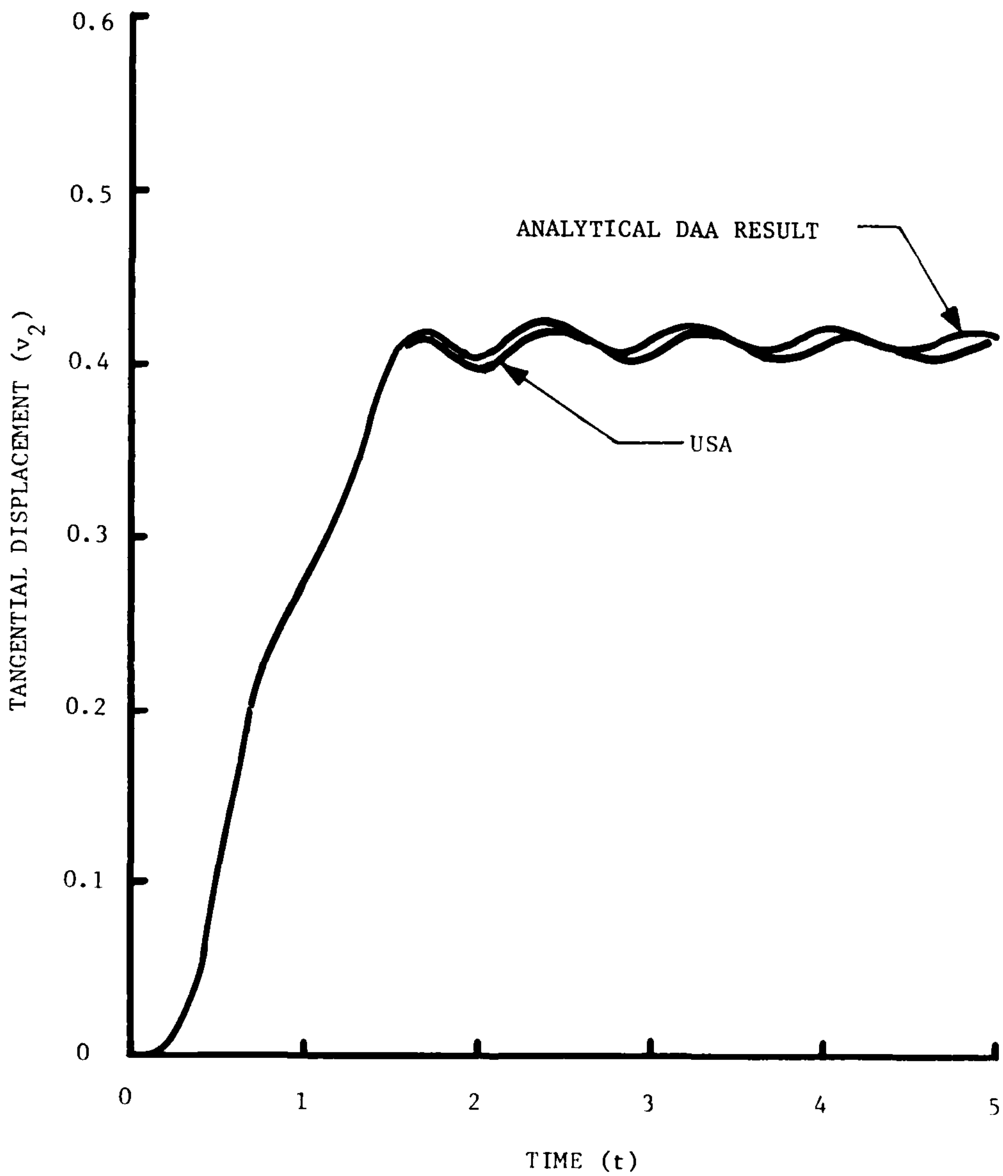

Figure 4-8 n=2 Tangential Displacement of Infinite Cylinder in Infinite Fluid

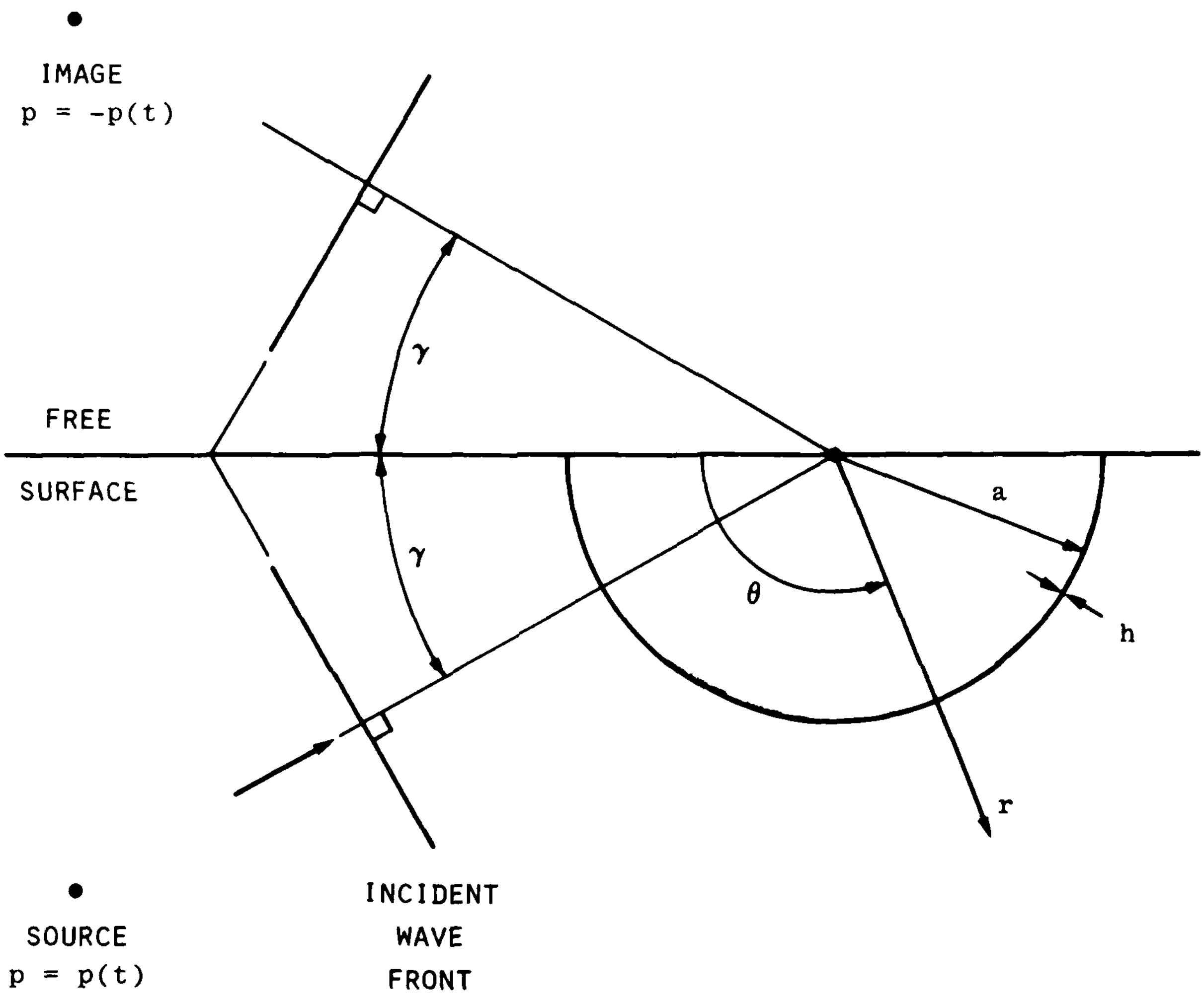

Figure 4-9 Geometry of Free Surface Problem for Plane Wave Impinging Upon Infinite Cylinder

$$\begin{Bmatrix} w(\theta,t) \\ v(\theta,t) \\ p(r,\theta,t) \\ p_I(r,\theta,t) \\ u_I(r,\theta,t) \end{Bmatrix} = \sum_{n=0}^{\infty} \begin{Bmatrix} w_n^c(t)\cos n\theta & w_n^s(t)\sin n\theta \\ v_n^s(t)\sin n\theta & v_n^c(t)\cos n\theta \\ p_n^c(t)\cos n\theta \quad + & p_n^s(t)\sin n\theta \\ p_{In}^c(r,t)\cos n\theta & p_{In}^s(r,t)\sin n\theta \\ u_{In}^c(r,t)\cos n\theta & u_{In}^s(r,t)\sin n\theta \end{Bmatrix} \tag{4.9}$$

where w and v are the radial and circumferential shell displacements, respectively, p is the total fluid pressure and p_I and u_I are the pressure and radial fluid-particle velocity of the incident wave. Because this is a linear problem, the solution consists of the superposition of two infinite-fluid solutions, the time-dependent part of which will be denoted by a superscript I. The result is

$$\begin{aligned} \begin{Bmatrix} w(\theta,t) \\ v(\theta,t) \\ p(r,\theta,t) \end{Bmatrix} &= \sum_{n=0}^{\infty} (-1)^n \begin{Bmatrix} w_n^I(t)\cos n(\theta-\gamma) \\ v_n^I(t)\sin n(\theta-\gamma) \\ p_n^I(r,t)\cos n(\theta-\gamma) \end{Bmatrix} \\ &- \sum_{n=0}^{\infty} (-1)^n \begin{Bmatrix} w_n^I(t)\cos n(\theta+\gamma) \\ v_n^I(t)\sin n(\theta+\gamma) \\ p_n^I(r,t)\cos n(\theta+\gamma) \end{Bmatrix} \end{aligned} \tag{4.10}$$

The multipliers $(-1)^n$ are required if the results of [3,4,30,32,33] are used to provide the infinite-fluid solutions for step-wave excitation. This is because of the convention adopted there that the incident wave first contacts the cylinder at $\theta = \pi$. It should be noted that (4.10) holds for any plane-wave input if the infinite-fluid solution can be found and no cavitation occurs in the fluid.

The trigonometric terms in (4.10) can easily be simplified to give

$$\begin{Bmatrix} w(\theta,t) \\ v(\theta,t) \\ p(r,\theta,t) \end{Bmatrix} = 2\sum_{n=1}^{\infty} (-1)^n \sin n\gamma \begin{Bmatrix} w_n^I(t)\sin n\theta \\ -v_n^I(t)\cos n\theta \\ p_n^I(r,t)\sin n\theta \end{Bmatrix} \tag{4.11}$$

Note from (4.10) that the solution for n=0 is identically zero. Also note that if the time-dependent part of the free surface solution is denoted by a superscript F, then

$$\begin{Bmatrix} w_n^F(t) \\ v_n^F(t) \\ p_n^F(r,t) \end{Bmatrix} = (-1)^n\, 2\sin n\gamma \begin{Bmatrix} w_n^I(t) \\ -v_n^I(t) \\ p_n^I(r,t) \end{Bmatrix} \tag{4.12}$$

This extremely simple result applies to exact solutions produced by the residual potential method [3,30,32], approximate solutions produced by the DAA [3,4], and the approximate post-envelopment solutions given in [33].

For a USA-Code treatment of this problem, a 40-node, 19-element SPAR half-model was constructed consisting of one 5° plate element, seventeen 10° plate-elements and a second 5° plate-element. The angle γ was taken as 45°. In other respects, this analysis paralleled that of the totally submerged cylindrical shell described in Subsection 4.2.

Velocity responses for n=1 are shown in Figures 4-10 and 4-11, while displacement results for n=2 are shown in Figures 4-12 and 4-13. The level of USA-Code error for n=1 is about 1%; it is of interest to note that the approximate asymptotic velocity provided by the analysis of [31] is $V_\infty = 2.623$, which is about 10% high.

The n=2 post-envelopment solution during the final phase of shell envelopment is quite sensitive to temporal and spatial discretization details. This sensitivity is reflected in the level of USA-Code error exhibited in Figures 4-12 and 4-13, and is associated with the pressure discontinuity at the front of the step-wave. The error here is somewhat greater than that in Figures 4-7 and 4-8, as both the incident wave and its negative image are now involved.

4.4 DAA_2 STUDIES

As an initial test of USA-DAA_2, the infinite-cylinder case has also been run and physical response variables have been Fourier-decomposed to produce modal responses. For comparison, corresponding exact solutions have been obtained analytically by the residual potential (RP) method [30]. Comparisons are shown in Figures 4-14 through 4-18.

The difference between the family of doubly asymptotic solutions and the exact solution shown in Figure 4-14 is intrinsic to the infinite cylinder and occurs because of the infinite value of the n=0 fluid mass coefficient. Hence the interaction consists only of the high frequency asymptote of the DAA family. For a finite cylinder, the fluid mass for the breathing mode is always finite, so that the low-frequency contribution of the DAA family does participate.

Velocity responses for n=1 are shown in Figures 4-15 and 4-16, where it is noted that $\eta=0$ (DAA_1) and $\eta = 1$ provide rather wide bounds on the exact solution in the intermediate time range, while a value of $\eta = 1/2$ is remarkably close to the exact solution. In Figures 4-17 and 4-18, the displacement responses do not show such wide differences between $\eta = 1/2$ and $\eta = 1$; however, they both demonstrate a striking superiority over the DAA_1 result. It would appear from this limited evidence that $\eta = 1/2$ is probably optimum for the infinite cylinder case.

In closing, it should be emphasized that a study of the stability of (2.34) and (2.35) has yet to be undertaken. However, the results obtained thus far are very encouraging in this regard. No indication of instability whatsoever was encountered in generating the infinite cylinder results in which the time step was doubled twice during the run, as was done in the DAA_1 runs.

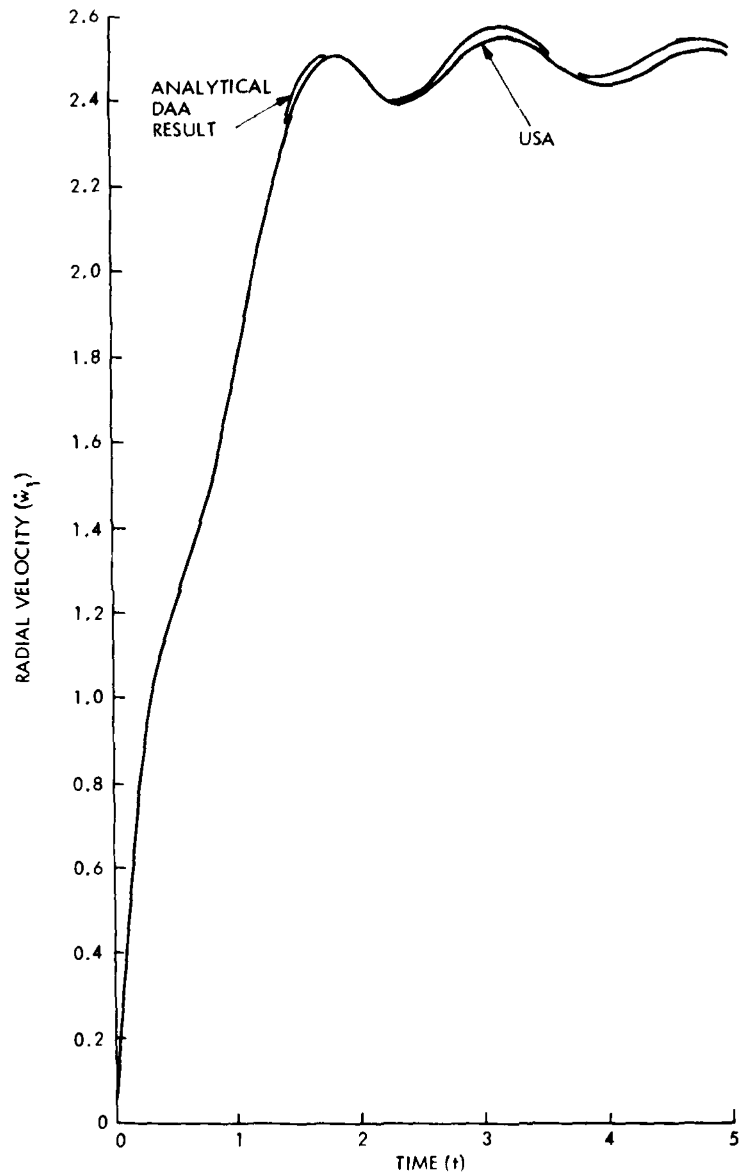

Figure 4-10 n=1 Radial Velocity of Infinite Cylinder at Surface of Semi-Infinite Fluid

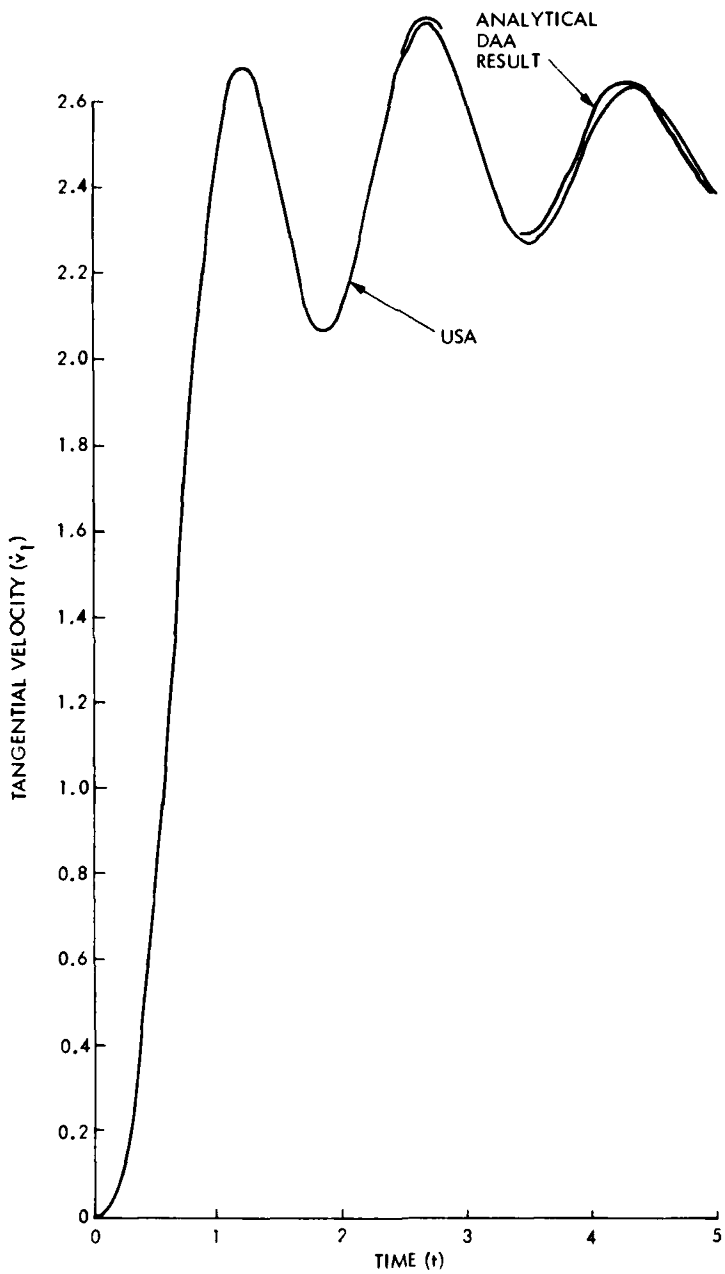

Figure 4-11 n=1 Tangential Velocity of Infinite Cylinder at Surface of Semi-Infinite Fluid

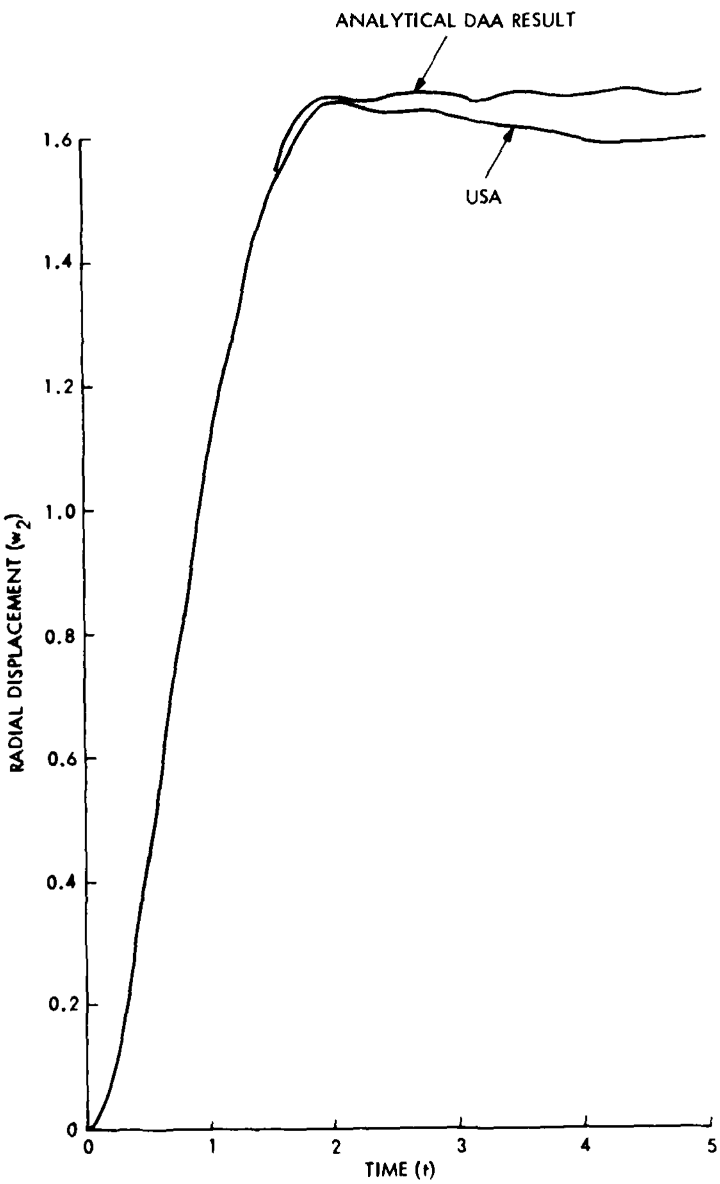

Figure 4-12 n=2 Radial Displacement of Infinite Cylinder at Surface of Semi-Infinite Fluid

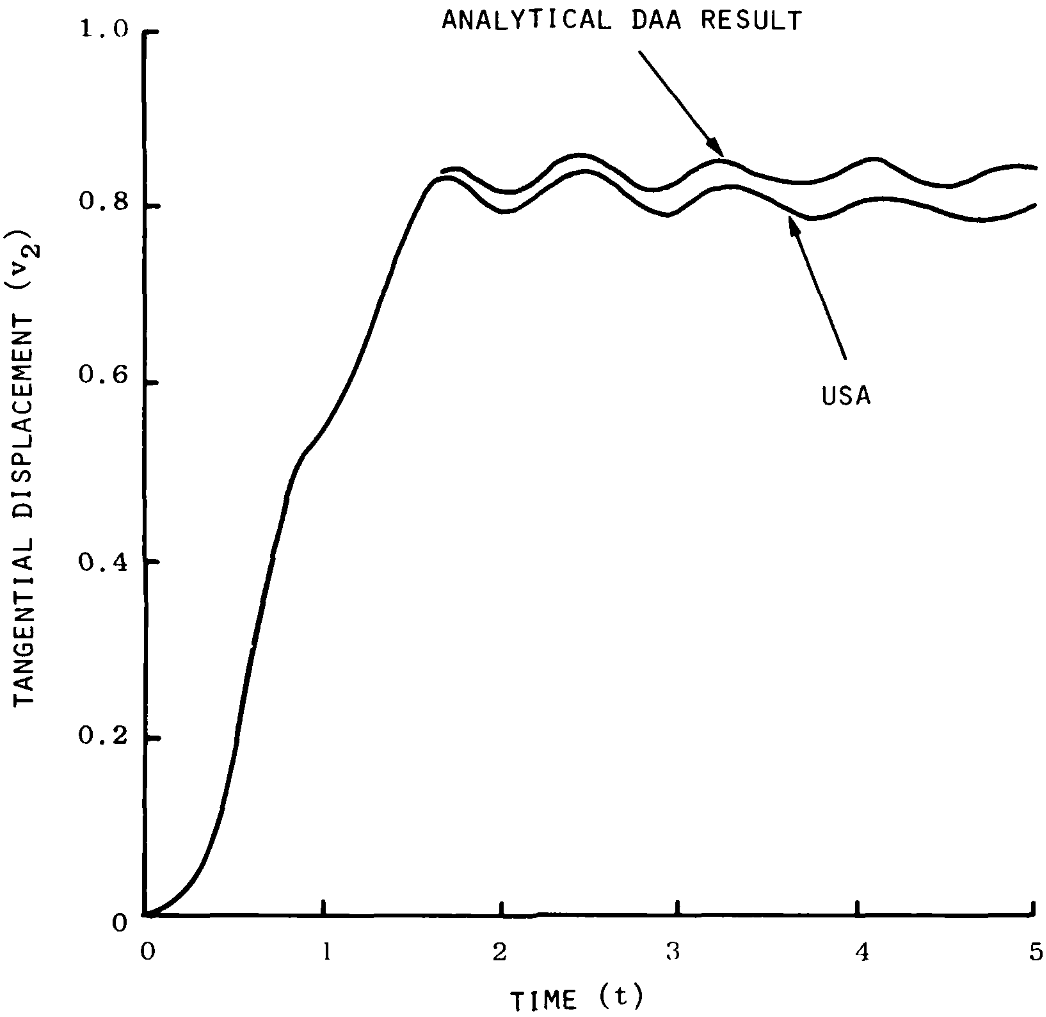

Figure 4-13 n=2 Tangential Displacement of Infinite Cylinder at Surface of Semi-Infinite Fluid

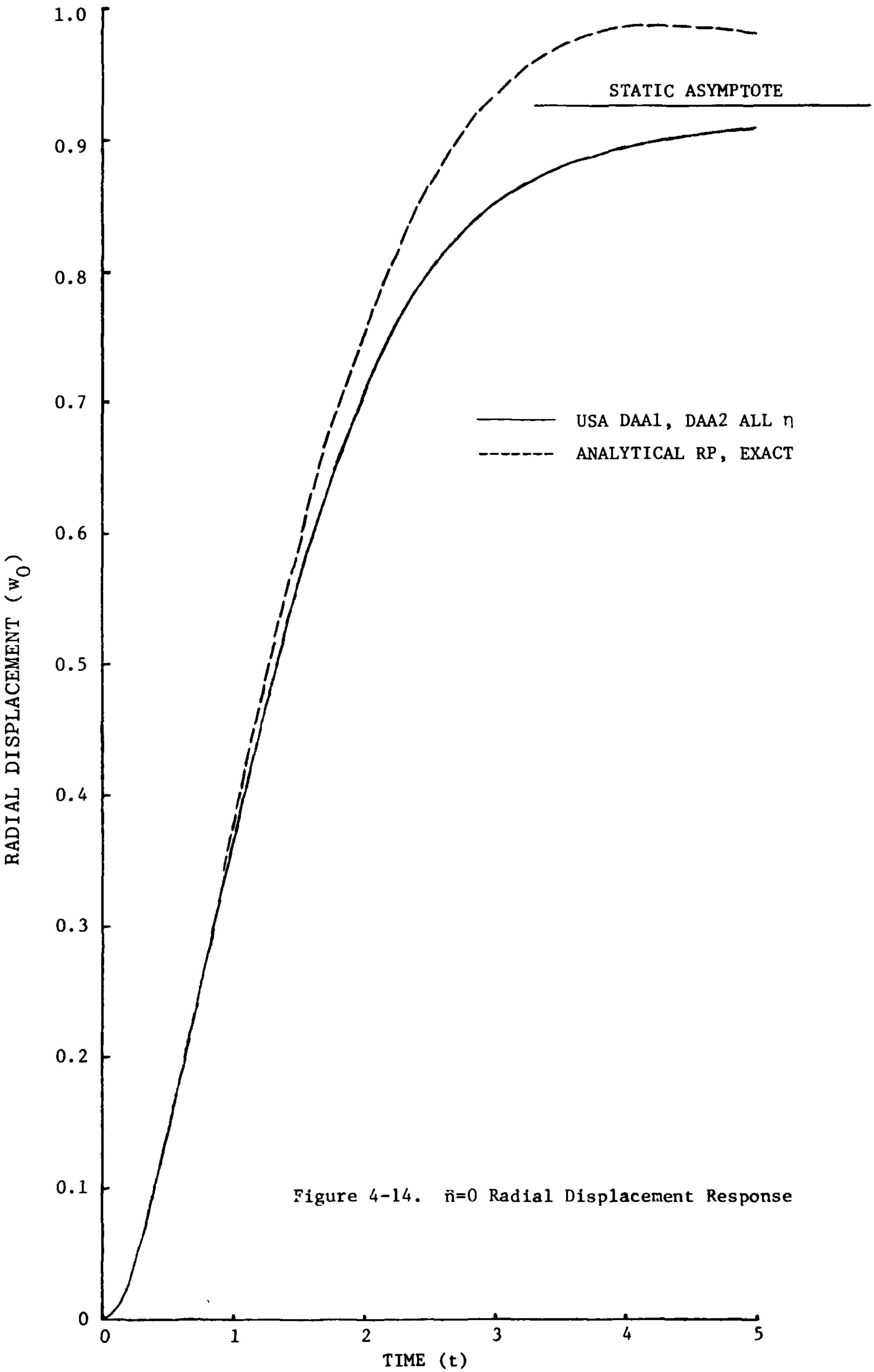

Figure 4-14. $\bar{n}$=0 Radial Displacement Response

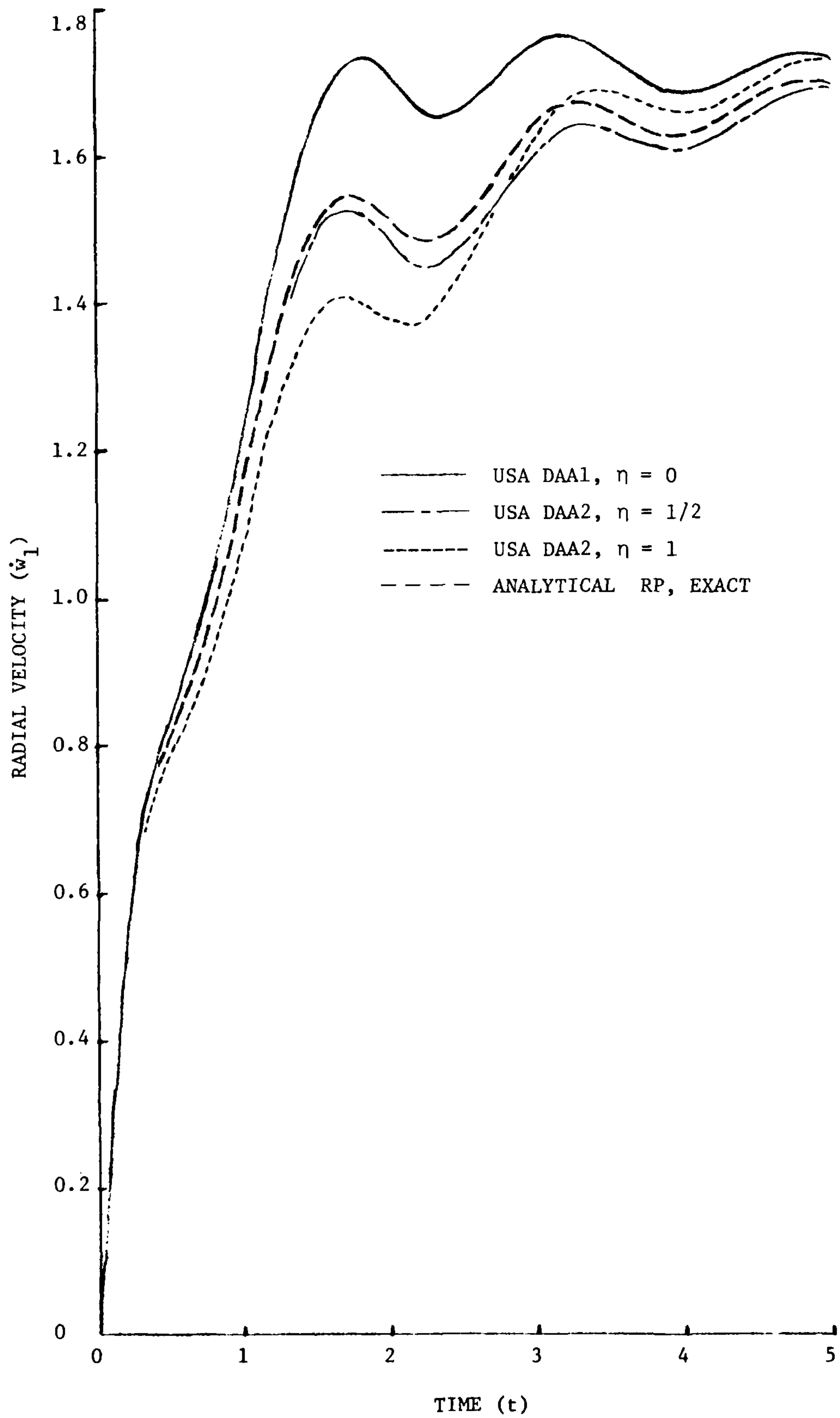

Figure 4-15. n=1 Radial Velocity Response

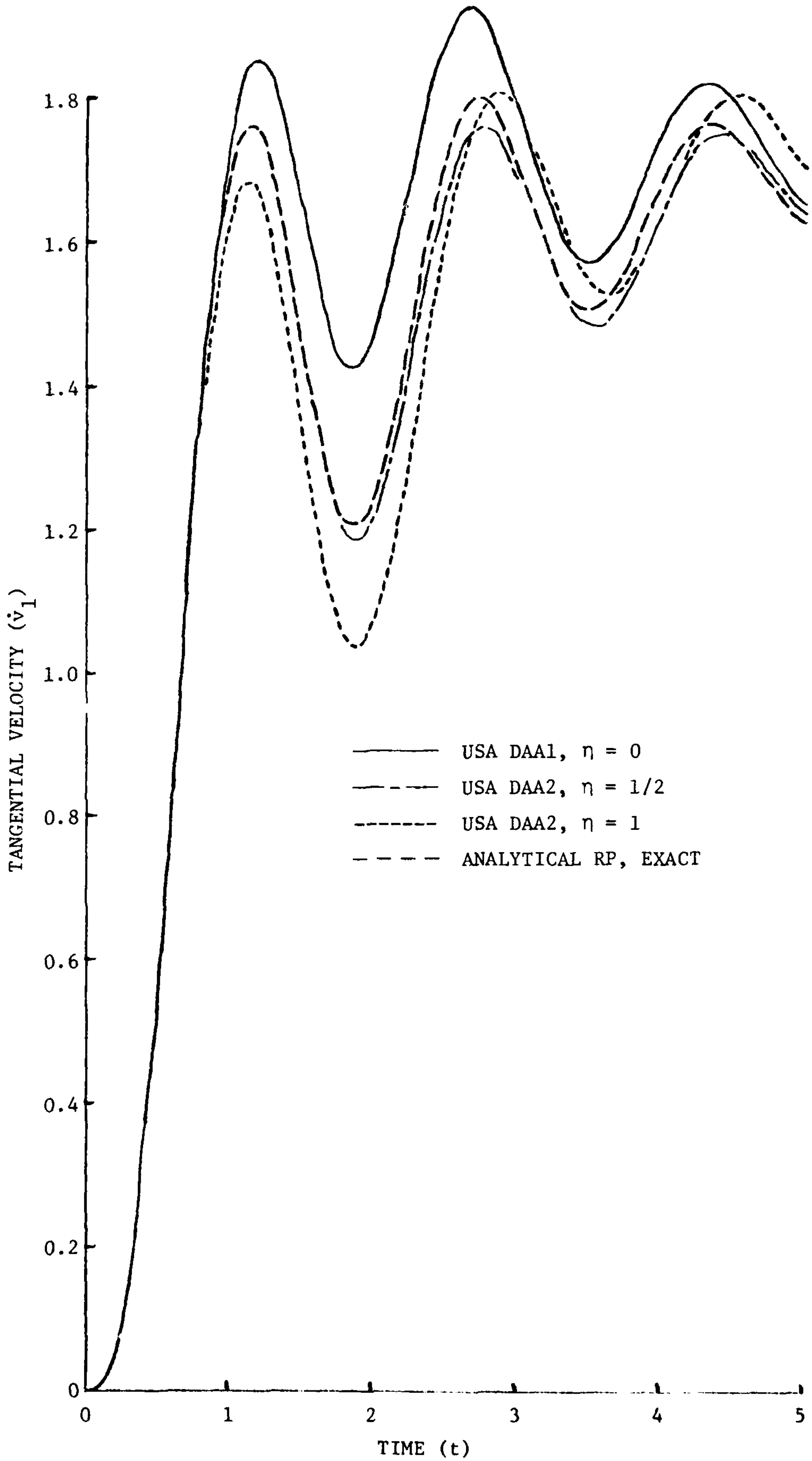

Figure 4-16. n=1 Tangential Velocity Response

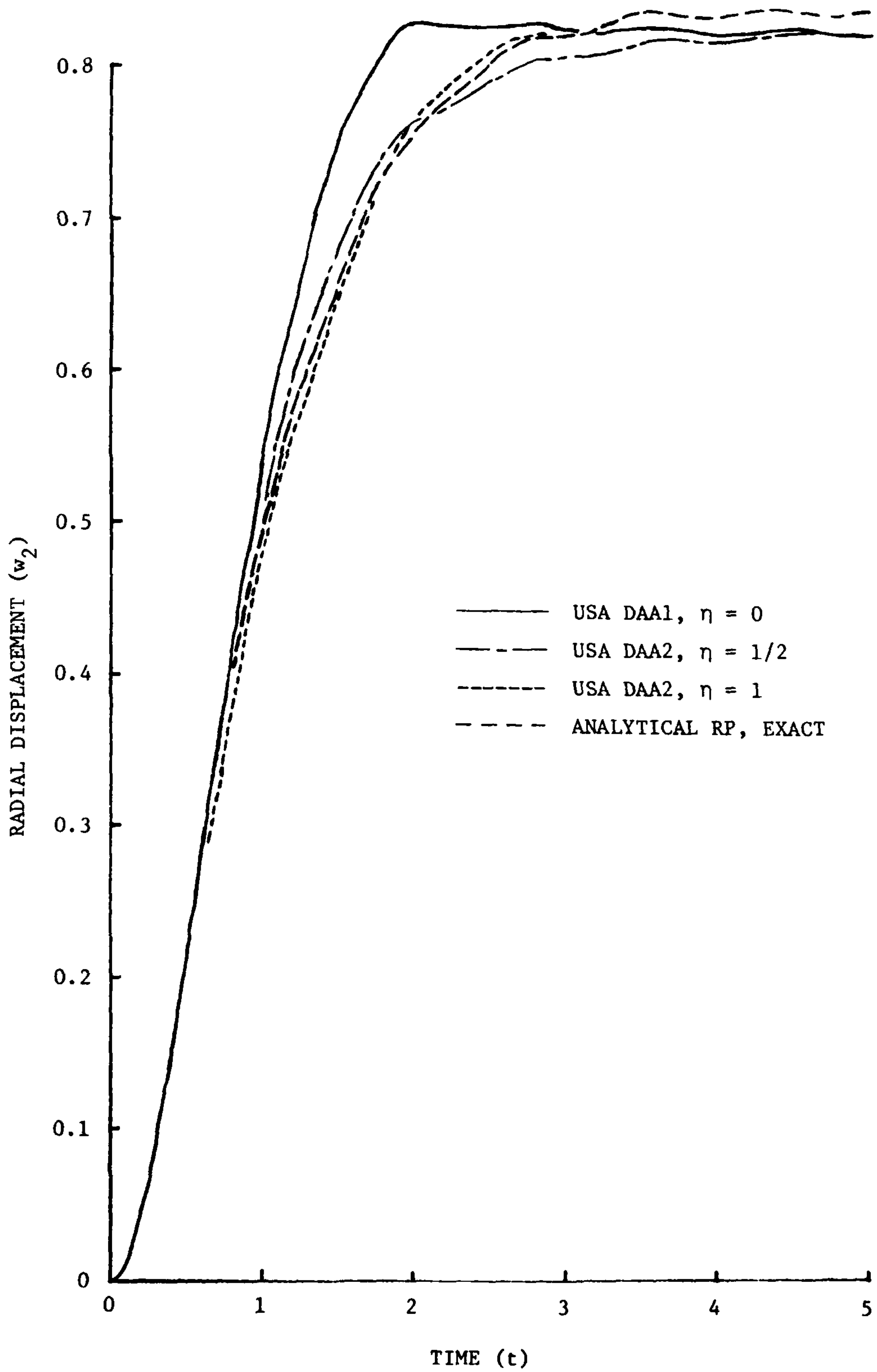

Figure 4-17. n=2 Radial Displacement Response

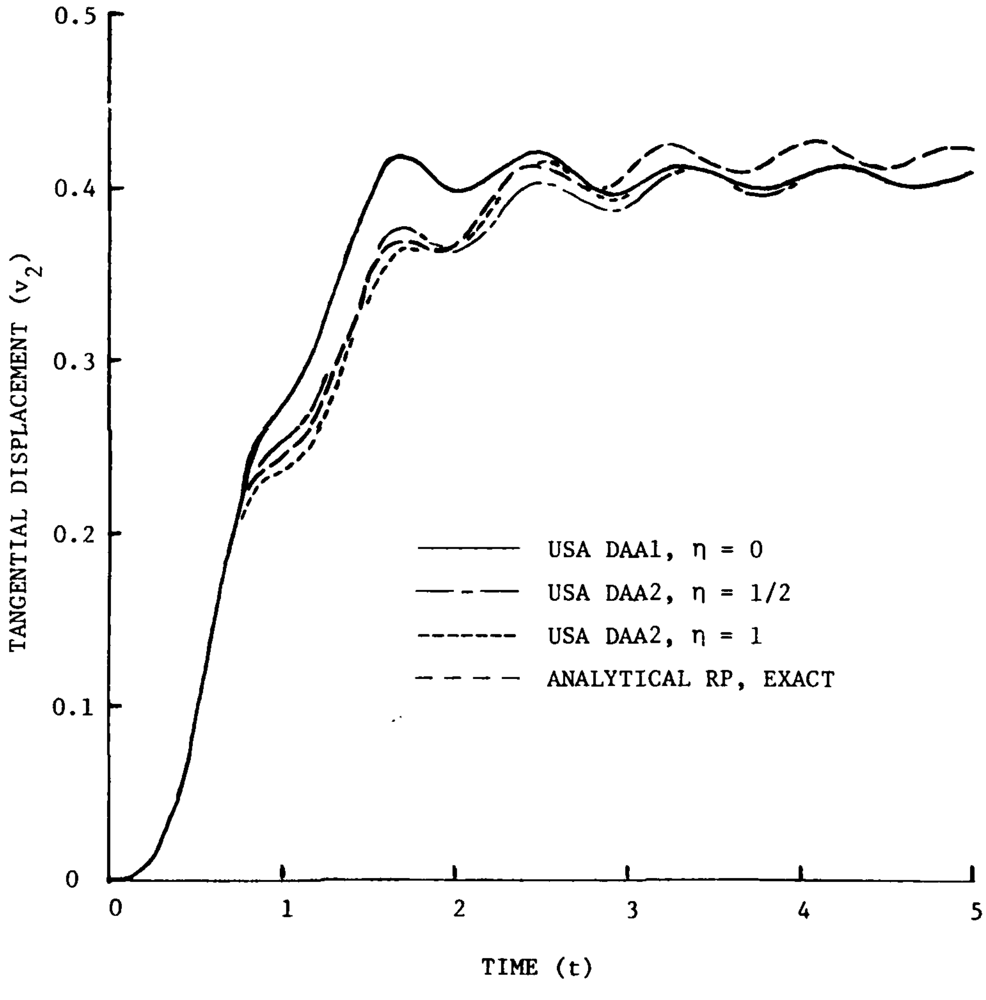

Figure 4-18. n=2 Tangential Displacement Response

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[33] T. L. Geers, "Response of an Elastic Cylindrical Shell to a Transverse Acoustic Shock Wave in a Light Fluid Medium", J. Acoust. Soc. Am., Vol. 48, No. 3 (Part 2), September 1970, pp. 692-701

APPENDIX A
USER INFORMATION FOR THE FLUID PREPROCESSOR FLUMAS

This appendix includes a copy of the users manual, and a sample input deck and subsequent output for the infinite cylindrical shell problem presented in Section 4.

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                              F L U M A S

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     THIS FUNCTIONAL COMPONENT OF THE UNDERWATER SHOCK ANALYSIS CODE
     CONSTRUCTS THE FLUID MASS MATRIX FOR A STRUCTURE SUBMERGED IN AN
     INFINITE. INVISCID. INCOMPRESSIBLE FLUID BY THE BOUNDARY ELEMENT
     TECHNIQUE. IT ALSO GENERATES FLUID MESH DATA AND A SET OF
     TRANSFORMATION COEFFICIENTS THAT RELATE THE STRUCTURAL AND FLUID
     DEGREES OF FREEDOM ON THE WET SURFACE. THE CODE HAS THE CAPABILITY
     TO TREAT STRUCTURES CONTAINING BOTH SURFACE-OF-REVOLUTION (SOR)
     AND GENERAL-GEOMETRY (GEN) COMPONENTS. THE CODE CAN CONSTRUCT THE
     FLUID MASS MATRIX FOR BOTH QUARTER AND HALF MODELS WITH
     ARBITRARILY ASSIGNED SYMMETRY OR ANTISYMMETRY CONDITIONS. AND CAN
     SIMULATE THE TWO-DIMENSIONAL PLANE STRAIN BEHAVIOR OF LONG
     CYLINDERS. THE PRESENCE OF A FREE SURFACE IN THE VICINITY OF THE
     SUBMERGED STRUCTURE CAN ALSO BE ACCOUNTED FOR. A VERY USEFUL
     DIAGNOSTIC TOOL CONTAINED WITHIN THE CODE IS THE ABILITY TO SOLVE
     THE FLUID BOUNDARY MODE EIGENVALUE PROBLEM

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     THIS PROGRAM WAS DEVELOPED AND CODED BY JOHN A. DERUNTZ. JR.
     OF LOCKHEED MISSILES AND SPACE CO  RESEARCH LABS IN PALO ALTO
     CALIFORNIA. PLEASE CONSULT WITH AUTHOR BEFORE MAKING CHANGES
     AND ALSO REPORT ANY MALFUNCTIONS OR PROBLEMS. WRITE IN CARE OF
     LOCKHEED PALO ALTO RESEARCH LABORATORY. BLDG 205. DEPT 52-33.
     3251 HANOVER ST.. PALO ALTO. CALIF.. 94304 OR CALL 415-493-4411
     EXTS. 45069 OR 45133.                           SEPTEMBER. 1980

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                        M A X I M U M    V A L U E S

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     MAXIMUM NUMBER OF STRUCTURAL GRID POINTS         . . . . . . .   1 0 0 0

     MAXIMUM NUMBER OF GENERAL SURFACE ELEMENTS       . . . . . . . .   4 0 0

     MAXIMUM NUMBER OF SURFACE OF REVOLUTION SEGMENTS   . . . . . .   2 0 0

     MAXIMUM NUMBER OF SURFACE OF REVOLUTION BRANCHES   . . . . . .       6

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  W A R N I N G    F R O M    T H E    P R O G R A M M E R    G E N E R A L

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     THIS CODE CONTAINS THE SPECIAL INGREDIENT DMGASP NOT FOUND IN
     OTHER BRANDS. DMGASP IS A DATA MANAGEMENT UTILITY MODULE THAT
     WILL ACTIVATE AND DEACTIVATE ALL AUXILIARY STORAGE DATA FILES
     REFERENCED BY THE CODE. HENCE THE NAMES OF SUCH FILES SHOULD NOT
     APPEAR ON ANY CONTROL CARDS IN THE RUN STREAM WHICH MIGHT NORMALLY
     ACTIVATE AND DEACTIVATE THE FILES. THE USER IS ALSO CAUTIONED THAT
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PREVIOUSLY CREATED FILES MUST ALREADY BE RESIDENT IN THE SYSTEM
BEFORE THE RUN IS INITIATED. IF A FILE HAS BEEN ROLLED-OUT TO TAPE
DMGASP WILL ATTEMPT TO HAVE THE FILE ROLLED-IN EVERY 15 SECONDS
FOR UP TO 6 MINUTES ON THE UNIVAC 1100-EXEC 8 OPERATING SYSTEM.
IF AN EXISTING DATA FILE HAS NOT BEEN REFERENCED FOR SOME TIME IT
IS THEREFORE GOOD POLICY TO SIMPLY ACTIVATE AND DEACTIVATE THE
FILE BEFORE EXECUTION OF THIS CODE. IF THE USER ATTEMPTS TO CREATE
A NEW DATA FILE WITH A NAME WHICH IS ALREADY ASSIGNED TO AN
EXISTING FILE, THE UNIVAC VERSION OF DMGASP WILL MODIFY THE NAME
OF THE FILE GENERATED BY THIS RUN TO AVOID ANY CONFLICT. FILE NAME
DUPLICATION WILL CAUSE NO PROBLEM ON THE CDC SCOPE OPERATING
SYSTEM AS SCOPE WILL SIMPLY CATALOG A NEW CYCLE OF THE SAME FILE.
ON THE OTHER HAND THE CDC NOS SYSTEM IS SIMILAR TO UNIVAC IN THIS
REGARD AND THE RUN WILL ABORT SINCE THE NAME-CHANGING FEATURE OF
DMGASP HAS NOT BEEN IMPLEMENTED FOR NOS. QUALIFIER*FILENAME IS THE
REQUIRED INPUT DATA FORMAT FOR ALL UNIVAC PERMANENT FILE NAMES.
ON CDC SCOPE, THE QUALIFIER IS INTERPRETED AS THE USERS ID, WHICH
IN MOST INSTALLATIONS CAN BE SELECTED ALMOST ARBITRARILY. ON CDC
NOS, THE QUALIFIER IS INTERPRETED AS THE USERS CATALOG NUMBER,
WHICH IS USUALLY PRESCRIBED BY THE INSTALLATION. A CYCLE NUMBER
CAN ALSO BE APPENDED TO GIVE THE FORM QUALIFIER*FILENAME(CYCLE)
ON CDC SCOPE

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                 P R O G R A M     S I Z E

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ALL ARRAYS REFERRENCED IN THIS CODE THAT ARE PROBLEM DEPENDENT
RESIDE IN BLANK COMMON. THE SIZE OF BLANK COMMON IS DETERMINED BY
A PARAMETER STATEMENT IN THE MAIN PROGRAM FOR THE UNIVAC 1100-OS
VERSION. HENCE A RECOMPILATION IS NECESSARY TO INCREASE OR
DECREASE CORE ALLOCATION. IN THE CDC 6600 VERSION RECOMPILATION IS
UNNECESSARY AS THE LENGTH OF BLANK COMMON IS SET BY A FIELD LENGTH
REQUEST IN THE CONTROL CARD DECK

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D E F I N I T I O N    O F    I N P U T    P A R A M E T E R S

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INPUT VARIABLE NAMES GIVEN BELOW ARE GENERALLY THOSE WHICH ARE
ALSO USED IN THE CODING AND THE VARIABLE TYPES CORRESPOND TO
STANDARD FORTRAN USAGE:

             A   -   ALPHANUMERIC
             E   -   FLOATING POINT
             F   -   FIXED POINT
             I   -   INTEGER
             L   -   LOGICAL

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VARIABLE     TYPE                 DESCRIPTION
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NSTRC         I      NUMBER OF STRUCTURAL NODE OR GRID POINTS
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                     WHOSE GLOBAL COORDINATES ARE TO BE READ AS
                     INPUT DATA FROM CARDS. AT THE VERY LEAST
                     THE SUM OF NSTRC AND NSTRF (SEE BELOW)
                     MUST INCLUDE ALL THE WET NODES, IE., THOSE
                     LYING ON THE FLUID-STRUCTURE CONTACT
                     BOUNDARY. IF THE ULTIMATE PURPOSE OF THIS
                     RUN IS TO CONDUCT AN UNDERWATER SHOCK
                     ANALYSIS WITH THE USA CODE FOR THE
                     STRUCTURE IN QUESTION THEN IT IS ADVISABLE
                     TO INCLUDE IN THE INPUT TO THIS PROCESSOR
                     ALL OF THE INTERNAL OR DRY STRUCTURAL NODE
                     POINTS AS WELL IN ORDER TO FACILITATE POST
                     PROCESSING OF THE TRANSIENT RESPONSE
                     ANALYSIS FOR THE DRY STRUCTURE. THIS
                     NUMBER MAY ALSO INCLUDE ADDITIONAL NODE
                     POINTS THAT ARE NOT PART OF THE STRUCTURAL
                     MODEL BUT WHICH ARE NECESSARY TO DEFINE
                     THE FLUID MESH. HOWEVER SUCH ADDITIONAL
                     NODES SHOULD APPEAR LAST AS THEY ARE NOT
                     REQUIRED BY ANY OTHER USA PROCESSOR AND
                     ARE THEREFORE ULTIMATELY DELETED

NSTRF       I        NUMBER OF STRUCTURAL NODE OR GRID POINTS
                     WHOSE GLOBAL COORDINATES ARE TO BE READ
                     FROM A PERMANENT FILE (SEE GRDNAM).
                     ADDITIONAL NODE POINTS THAT ARE NOT PART
                     OF THE STRUCTURAL MODEL ARE NOT PERMITTED
                     IN THIS DATA SET IF ACTUAL STRUCTURAL NODE
                     POINT DATA IS ALSO INPUT FROM CARDS. THIS
                     IS DUE TO THE FACT THAT THE FILE DATA IS
                     READ FIRST THEN THE DATA FROM CARDS AND
                     ANY ADDITIONAL NON-STRUCTURAL NODE POINTS
                     MUST APPEAR LAST IN THE GRID POINT LIST.
                     THIS FILE MUST ALWAYS BE REFERENCED WHEN
                     INTERFACING WITH STAGS

NGEN        I        NUMBER OF GENERAL FLUID DEGREES OF FREEDOM
                     WHOSE ASSOCIATED ELEMENTS CANNOT BE FORMED
                     BY AN AUTOMATIC MESH GENERATION PROCEDURE

NBRA        I        NUMBER OF DISTINCT SURFACE OF REVOLUTION
                     AXES OR BRANCHES

NCYL        I        NUMBER OF GENERAL FLUID CONTROL POINTS
                     WHICH LIE ON A RIGHT CIRCULAR CYLINDRICAL
                     SURFACE WHOSE ASSOCIATED RECTANGULAR
                     ELEMENTS COVER THE ENTIRE LATERAL SURFACE.
                     SUCH ELEMENTS CAN BE FORMED BY AN
                     AUTOMATIC MESH GENERATION SCHEME WHICH IS
                     EMBEDDED IN THE CODE. STRUCTURAL GRID
                     POINT COORDINATES NEED NOT BE INPUT IN
                     THIS CASE UNLESS DICTATED BY OTHER
                     CIRCUMSTANCES

NHAS        I        STARTING CIRCUMFERENTIAL HARMONIC FOR
                     SURFACE OF REVOLUTION ELEMENTS

NHAF        I        FINAL CIRCUMFERENTIAL HARMONIC FOR
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SURFACE OF REVOLUTION ELEMENTS

NHAI	I	INCREMENT TO BE APPLIED IN ASSIGNING CIRCUMFERENTIAL HARMONICS IN THE RANGE FROM NHAS TO NHAF
NFUN	I	NUMBER OF TRIGONOMETRIC FUNCTIONS THAT WILL BE USED IN ASSIGNING SURFACE OF REVOLUTION FLUID DEGREES OF FREEDOM. PERMISSIBLE VALUES ARE: 1 - EITHER SINE OR COSINE WILL BE USED ACCORDING TO VALUE OF ITRG DESCRIBED BELOW 2 - BOTH SINE AND COSINE FUNCTIONS WILL BE USED
ITRG	I	IF NFUN = 1 ITRG DESIGNATES THE PARTICULAR TRIGONOMETRIC FUNCTION TO BE USED FOR SURFACE OF REVOLUTION FLUID DEGREES OF FREEDOM. ALLOWABLE VALUES ARE: 1 - COSINE FUNCTION IS USED 2 - SINE FUNCTION IS USED
NSEG	I	NUMBER OF SURFACE OF REVOLUTION SEGMENTS ALONG ANY PARTICULAR AXIS OR BRANCH
NCIR	I	NUMBER OF SUB-ELEMENTS AROUND THE CIRCUMFERENCE OF A SURFACE OF REVOLUTION BRANCH. UNDER NORMAL CONDITIONS USE A VALUE OF ZERO AND THE CODE WILL CHOOSE AN APPROPRIATE VALUE BASED UPON THE ASPECT RATIO OF THE SUB-ELEMENT. A MINIMUM OF TWELVE (12) IS ALLOWED AND NCIR IS ALWAYS A MULTIPLE OF FOUR (4). USE A NON-ZERO VALUE ONLY UNDER SPECIAL CIRCUMSTANCES AND ADHERE TO THESE GUIDELINES
RHO	E,F	FLUID MASS DENSITY
CEE	E,F	FLUID SPEED OF SOUND
DAA2	E,F	A PARAMETER BOUNDED BY ZERO AND UNITY THAT GOVERNS THE USE OF THE IMPROVED DOUBLY ASYMPTOTIC APPROXIMATION. A VALUE OF ZERO REDUCES THE FLUID SOLUTION TO THE STANDARD DOUBLY ASYMPTOTIC APPROXIMATION. HOWEVER A PRECISE CHOICE FOR THIS PARAMETER IS NOT GIVEN BY ANY FUNDAMENTAL PRINCIPLE. IT HAS BEEN OBSERVED THAT A VALUE OF 1.0 LEADS TO THE BEST ACCURACY FOR A SPHERICAL SHELL WHILE A VALUE OF 0.5 SEEMS TO BE BEST FOR THE INFINITE CYLINDRICAL SHELL. IT CAN BE SHOWN THAT THIS SCALAR PARAMETER DOES HAVE A RELATIONSHIP WITH THE DIAGONAL LOCAL CURVATURE MATRIX FOR THE FLUID ELEMENTS. IF DAA2 RUNS ARE CONTEMPLATED AS WELL AS

		DAA1 RUNS IT IS ADVISEABLE TO ENTER A NONZERO VALUE AND THE PRECISE VALUE CAN BE CHANGED LATER IN THE AUGMAT PROCESSOR IF NECESSARY. IF A ZERO VALUE IS ENTERED THEN TWO MATRICES REQUIRED FOR DAA2 EXECUTION ARE NOT EVEN CONSTRUCTED
PRTGMT	L	TRUE IF FLUID MESH GEOMETRY DATA IS TO BE LISTED, OTHERWISE FALSE
PRTTRN	L	TRUE IF FLUID-STRUCTURE TRANSFORMATION DATA IS TO BE LISTED, OTHERWISE FALSE
PRTAMF	L	TRUE IF FLUID MASS MATRIX IS TO BE LISTED, OTHERWISE FALSE IN WHICH CASE ONLY THE DIAGONAL TERMS ARE PRINTED. THIS PARAMETER ALSO GOVERNS THE PRINTING OF THE MATRIX THAT APPEARS IN THE DAA EQUATIONS
CALCAM	L	TRUE IF THE FLUID MASS MATRIX IS TO BE COMPUTED, OTHERWISE FALSE AND THE RUN WILL TERMINATE AFTER THE FLUID MESH GEOMETRY DATA HAS BEEN PROCESSED. USE A VALUE OF TRUE ONLY AFTER DEBUGGING OF THE GEOMETRY DATA HAS BEEN COMPLETED
PRTCOE	L	TRUE IF THE B AND C MATRICES ARE TO BE PRINTED FOR SOME DIAGNOSTIC REASON, OTHERWISE FALSE UNDER NORMAL OPERATING CONDITIONS. THESE MATRICES ARE FULL AND GENERALLY NONSYMMETRIC. THE PRODUCT B*CINV IS THE PRINCIPAL COMPUTATION THAT IS REQUIRED TO FORM THE FLUID MASS MATRIX (SEE DERUNTZ AND GEERS, ADDED MASS COMPUTATION BY THE BOUNDARY INTEGRAL METHOD, INT J NUM METH, VOL 12, 1978, PP 531-550)
EIGMAF	L	TRUE IF EIGENVALUES AND EIGENVECTORS OF THE FLUID BOUNDARY MODE PROBLEM ARE DESIRED, OTHERWISE FALSE. THE PRESENCE OF NEGATIVE EIGENVALUES IS AN INDICATION THAT THE FLUID MESH IS IN ERROR, HENCE THIS CAN BE AN IMPORTANT DEBUGGING TOOL
TWODIM	L	TRUE IF A TWO DIMENSIONAL PLANE STRAIN FLUID MASS MATRIX IS REQUIRED, OTHERWISE FALSE. THE Z DIRECTION MUST BE PERPENDICULAR TO THE PLANE OF THE FLUID MODEL. IF THIS IS NOT SO A TEMPORARY OR PERMANENT COORDINATE ROTATION CAN BE APPLIED FOR COMPUTATION OF THE MATRIX (SEE ROTQUA OR ROTGLO)
HAFMOD	L	TRUE IF THE FLUID MESH INPUT GEOMETRY CORRESPONDS TO A HALF MODEL, OTHERWISE FALSE. THE VARIABLES DEPTH, CXFS, CYFS, AND CZFS ARE USED TO DEFINE THE LOCATION

		AND ORIENTATION OF THE SYMMETRY PLANE. THIS OPTION CANNOT BE USED SIMULTANEOUSLY WITH FRESUR = .TRUE.
QUAMOD	L	TRUE IF THE FLUID MESH INPUT GEOMETRY CORRESPONDS TO A QUARTER MODEL, OTHERWISE FALSE. THE XZ AND YZ PLANES ARE CONSIDERED TO BE THE PLANES OF SYMMETRY OF THE MODEL BY DEFAULT. IF NECESSARY A COORDINATE ROTATION CAN BE APPLIED TO SATISFY THIS REQUIREMENT (SEE ROTQUA BELOW). IF NCYL IS NOT EQUAL TO ZERO SUCH A ROTATION MUST BE USED IN CONJUNCTION WITH THE QUARTER MODEL. THIS ROTATION WILL NOT AFFECT THE ORIENTATION OF THE FLUID MESH REFERENCE AXES IN SUBSEQUENT USA PROCESSING
PCHCDS	L	TRUE IF THE DIAGONAL GENERALIZED AREA MATRIX IS TO BE PUNCHED OUT ON CARDS FOR INPUT TO NASTRAN, OTHERWISE FALSE
NASTAM	L	TRUE IF THE FLUID MASS MATRIX OR ITS MANIPULATED FORM WHICH APPEARS IN THE DAA EQUATION IS TO BE PUT IN THE PERMANENT FILE DESIGNATED BY FLUNAM IN A FORMAT WHICH CAN BE READ BY NASTRAN, OTHERWISE FALSE
STOMAS	L	TRUE IF THE FLUID MASS MATRIX ITSELF IS TO BE PUT IN PERMANENT STORAGE, OTHERWISE FALSE. IN CONTRAST TO EARLIER VERSIONS OF THIS CODE THIS PARAMETER CAN BE SET TO FALSE FOR NORMAL OPERATION OF THE USA CODE
STOINV	L	TRUE IF THE MANIPULATED FORM OF THE FLUID MASS MATRIX WHICH APPEARS IN THE DAA EQUATION IS TO BE PUT IN PERMANENT STORAGE, OTHERWISE FALSE. THIS MATRIX CONSISTS OF THE INVERTED FLUID MASS MATRIX THAT HAS BEEN PRE- AND POST-MULTIPLIED BY THE DIAGONAL FLUID ELEMENT AREA MATRIX AND THEN MULTIPLIED BY BOTH THE MASS DENSITY AND THE SPEED OF SOUND OF THE FLUID. IN CONTRAST WITH EARLIER VERSIONS OF THIS CODE THIS PARAMETER MUST BE SET TO TRUE FOR NORMAL OPERATION OF THE USA CODE
FRWTFL	L	TRUE IF THE PERMANENT FILE CONTAINING THE FLUID MASS MATRIX OR ITS MANIPULATED FORM IS TO BE CREATED BY BUFFERED, UNFORMATTED FORTRAN WRITE STATEMENTS, OTHERWISE FALSE AND DMGASP WILL CREATE THE FILE
FRWTGE	L	TRUE IF THE PERMANENT FILE CONTAINING THE FLUID MESH GEOMETRY IS TO BE CREATED BY BUFFERED, UNFORMATTED FORTRAN WRITE STATEMENTS, OTHERWISE FALSE AND DMGASP WILL CREATE THE FILE

FRWTGR	L	TRUE IF THE PERMANENT FILE CONTAINING STRUCTURAL GRID POINT COORDINATES HAS BEEN CREATED BY BUFFERED, UNFORMATTED FORTRAN WRITE STATEMENTS, OTHERWISE FALSE IN WHICH CASE IT IS ASSUMED THAT DMGASP WAS USED TO CREATE THE FILE. CONSULT A LISTING OF THE SUBROUTINE READST FOR THE FILE STRUCTURE THAT IS EXPECTED WHICH DIFFERS FOR THE TWO POSSIBLE CASES. THIS FILE MUST EXIST FOR INTERFACING WITH STAGS
FRESUR	L	TRUE IF FREE SURFACE EFFECTS ARE TO BE INCLUDED IN THE FLUID MASS MATRIX, OTHERWISE FALSE. THE VARIABLES DEPTH, CXFS, CYFS, AND CZFS ARE USED TO DEFINE THE LOCATION AND ORIENTATION OF THE FREE SURFACE. THIS OPTION CANNOT BE USED SIMULTANEOUSLY WITH HAFMOD = .TRUE.
RENUMB	L	TRUE IF SOME RENUMBERING OF THE STRUCTURAL NODE NUMBERS MUST BE CARRIED OUT AFTER THE FLUID-STRUCTURE TRANSFORMATION DATA HAS BEEN GENERATED, OTHERWISE FALSE. THIS OPTION IS IMPORTANT IF THE USE OF A PARTICULAR STRUCTURAL NODE NUMBER IS CONVENIENT TO DEFINE THE FLUID MESH BUT, INSTEAD, A NEARBY STRUCTURAL NODE SHOULD BE USED FOR FORCE APPLICATION DURING THE UNDERWATER SHOCK ANALYSIS TIME INTEGRATION RUN. THIS CASE IS PARTICULARLY IMPORTANT IF THE TWO POINTS IN QUESTION ARE JOINED BY A RIGID LINK AND THE STUCTURAL POINT ORIGINALLY USED TO DEFINE THE FLUID MESH IS ELIMINATED FROM THE STIFFNESS MATRIX BY A CONSTRAINT EQUATION. WITHOUT THE USE OF THIS OPTION THE APPROPRIATE FORCE WOULD NOT BE APPLIED TO THE EQUATIONS OF MOTION
STOGMT	L	TRUE IF THE FLUID MESH GEOMETRY AND FLUID-STRUCTURE TRANSFORMATION DATA IS TO PUT IN PERMANENT STORAGE, OTHERWISE FALSE
ROTGEO	L	TRUE IF THE FLUID MESH GEOMETRY IS TO BE REFERRED TO A SET OF GLOBAL COORDINATE AXES WHICH IS DIFFERENT FROM THAT OF THE BASIC INPUT DATA FOR ALL SUBSEQUENT USA PROCESSING (SEE GEOANG), OTHERWISE FALSE
ROTQUA	L	TRUE IF THE FLUID MESH GEOMETRY IS TO BE REFERRED TO A SET OF GLOBAL COORDINATE AXES WHICH IS DIFFERENT FROM THAT OF THE BASIC INPUT DATA ONLY FOR COMPUTATION OF THE FLUID MASS MATRIX (SEE QUAANG), OTHERWISE FALSE. THIS OPTION IS TO BE USED IF A QUARTER MODEL IS REQUIRED AND THE INPUT DATA REFERENCE AXES DO NOT COINCIDE WITH THE DEFAULT SYMMETRY AXES. THIS

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                            FEATURE CAN ALSO BE USED IN CONJUNCTION
                            WITH THE TWO DIMENSIONAL PLANE STRAIN
                            MODEL AS WELL (SEE TWODIM)

FLUNAM        A             NAME OF PERMANENT MASS STORAGE FILE WHICH
                            WILL CONTAIN THE FLUID MASS MATRIX

GEONAM        A             NAME OF PERMANENT MASS STORAGE FILE WHICH
                            WILL CONTAIN THE FLUID MESH GEOMETRY AND
                            FLUID-STRUCTURE TRANSFORMATION DATA

GRDNAM        A             NAME OF PERMANENT MASS STORAGE FILE WHICH
                            CONTAINS THE GLOBAL COORDINATES OF THE
                            STRUCTURAL GRID POINTS

DAANAM        A             NAME OF PERMANENT MASS STORAGE FILE WHICH
                            WILL CONTAIN THE MANIPULATED DAA FORM OF
                            THE FLUID MASS MATRIX

NVEC          I             NUMBER OF FLUID BOUNDARY MODE EIGENVECTORS
                            DESIRED. THESE ARE ORDERED STARTING WITH
                            THE LOWEST ORDER MODES FIRST. IF ALL THE
                            MODES ARE DESIRED THE USER CAN JUST SET
                            NVEC TO 1000 AND THE CODE WILL
                            AUTOMATICALLY REDUCE THIS NUMBER TO THE
                            ORDER OF THE FLUID MASS MATRIX. THIS IS
                            CONVENIENT WHEN THE MODEL CONTAINS SOR
                            ELEMENTS FOR SEVERAL HARMONICS AND/OR
                            BRANCHES AND THE USER DOES NOT WANT TO
                            SPEND TIME COUNTING UP THE TOTAL. THIS IS
                            RECOMMENDED ONLY FOR SMALL OR INTERMEDIATE
                            SIZE PROBLEMS. FOR LARGE PROBLEMS PRINTING
                            OF ONLY THE FIRST 10 EIGENVECTORS IS
                            RECOMMENDED. AS IT IS ONLY THE FIRST FEW
                            ARE GENERALLY USEFUL TO VERIFY SYMMETRIES
                            OR OTHER FEATURES OF THE MODEL. THE FIRST
                            ONE IS ALWAYS A BREATHING TYPE MODE UNLESS
                            THE FLUID MODEL CONSISTS SOLELY OF BEAM
                            TYPE SOR ELEMENTS

NUMZ          I             NUMBER OF FICTITIOUS ELEMENTS TO BE ADDED
                            IN AXIAL DIRECTION WHICH INCREASE THE
                            HALF LENGTH OF THE SURFACE FOR THE
                            SIMULATION OF A TWO DIMENSIONAL PLANE
                            STRAIN FLUID MASS MATRIX. THESE ELEMENTS
                            DO NOT INTRODUCE NEW DEGREES OF FREEDOM

ZLEN          E,F           LENGTH OF FICTITIOUS AXIAL ELEMENTS USED
                            IN THE SIMULATION OF A TWO DIMENSIONAL
                            PLANE STRAIN FLUID MASS MATRIX

CQ            E,F           USED FOR FLUID MESH MODELS WITH PLANES OF
                            SYMMETRY. CQ TAKES ON THE VALUE OF EITHER
                            PLUS OR MINUS ONE TO DENOTE SYMMETRIC OR
                            ANTISYMMETRIC FLOW CONDITIONS IN EACH
                            FLUID REGION INCLUDING THOSE THAT ARE NOT
                            EXPLICITLY CONTAINED IN THE MODEL. FOR A
                            QUARTER MODEL 4 VALUES ARE REQUIRED. ONE
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		FOR EACH QUADRANT. ONLY 2 VALUES ARE NECESSARY FOR A HALF MODEL
DEPTH	E,F	MAGNITUDE OF PERPENDICULAR DISTANCE FROM THE ORIGIN OF COORDINATES TO THE PLANE OF A FREE SURFACE OR THE PLANE OF SYMMETRY FOR A HALF MODEL
CXFS, CYFS, CZFS	E,F	DIRECTION COSINES OF A UNIT VECTOR NORMAL TO THE PLANE OF A FREE SURFACE OR THE PLANE OF SYMMETRY FOR A HALF MODEL AND POINTING OUT OF THE FLUID REGION EXPLICITLY CONTAINED IN THE MODEL. THEY MUST BE RELATIVE TO THE GLOBAL CARTESIAN COORDINATES OF THE FLUID MESH. IF ANY COORDINATE ROTATIONS ARE APPLIED TO THE FLUID MESH GEOMETRY (SEE ROTGEO AND ROTQUA) THESE QUANTITIES WILL ALSO BE TRANSFORMED
PATM	E,F	AMBIENT ATMOSPHERIC PRESSURE THAT IS USED ULTIMATELY TO TEST FOR BULK CAVITATION IN THE UNDERWATER SHOCK ANALYSIS
GRAVAC	E,F	ACCELERATION DUE TO GRAVITY
GEOANG	E,F	EULERIAN ANGLES OF ROTATION USED TO DESCRIBE A PERMANENT COORDINATE TRANSFORMATION FOR THE FLUID MESH GEOMETRY. THREE VALUES EXPRESSED IN DEGREES ARE REQUIRED. THE FIRST IS THE ROTATION ABOUT THE ORIGINAL X AXIS. THE SECOND IS THE ROTATION ABOUT THE LINE COINCIDENT WITH THE CURRENT ORIENTATION OF THE ORIGINAL Y AXIS AFTER THE FIRST ROTATION. AND FINALLY THE THIRD IS THE ROTATION ABOUT THE LINE COINCIDENT WITH THE CURRENT ORIENTATION OF THE ORIGINAL Z AXIS AFTER THE FIRST TWO ROTATIONS. ALTHOUGH THIS METHOD MAY BE SOMEWHAT CUMBERSOME FOR ARBITRARY SPATIAL ORIENTATIONS ALMOST ALL CASES OF PRACTICAL INTEREST WILL DEAL ONLY WITH VALUES OF 0, 90, AND/OR 180 DEGREES
QUAANG	E,F	EULERIAN ANGLES OF ROTATION USED TO DESCRIBE A TEMPORARY COORDINATE TRANSFORMATION FOR THE FLUID MESH GEOMETRY (SEE GEOANG ABOVE FOR PRECISE DEFINITION). IF A QUARTER MODEL IS REQUIRED AND THE MESH HAS BEEN GENERATED AUTOMATICALLY FOR A CYLINDRICAL SURFACE BOUNDED BY 0 AND 180 DEGREES THEN THE APPROPRIATE ANGLES TO USE HERE WOULD BE 90, 90, AND 0
NSHIFT	I	A PARAMETER THAT IS ADDED TO THE VALUE OF NLAST (SEE BELOW) IN THE NUMBERING OF

		FLUID ELEMENTS AUTOMATICALLY GENERATED FOR CYLINDRICAL SURFACES. THIS OPTION IS USEFUL IF A FLUID MESH HAS BEEN CONSTRUCTED WITH BOTH GEN ELEMENTS AND CYLINDRICAL SURFACE ELEMENTS AND THEN GEN ELEMENTS ARE REMOVED OR ADDED LATER IN A REMODELING EFFORT. SINCE GEN ELEMENTS APPEAR FIRST IN THE ELEMENT LIST THE USE OF THIS PARAMETER ELIMINATES ANY NEED TO CHANGE THE NUMBERING SCHEME ON DATA CARDS FOR CYLINDRICAL SURFACE ELEMENTS. NSHIFT MAY BE POSITIVE, NEGATIVE, OR ZERO
NSEQ	I	STRUCTURAL GRID POINT NUMBER
NS	I	INDICATOR TO DENOTE TYPE OF COORDINATE SYSTEM GRID POINT DATA IS REFERRED TO. ALLOWABLE VALUES ARE: 0 - GLOBAL CARTESIAN 1 - POLAR CYLINDRICAL. AXIS IN GLOBAL X DIRECTION 2 - POLAR CYLINDRICAL. AXIS IN GLOBAL Y DIRECTION 3 - POLAR CYLINDRICAL. AXIS IN GLOBAL Z DIRECTION
XC,YC,ZC	E,F	CARTESIAN COORDINATES OF STRUCTURAL GRID POINT IF NS = 0. IF NS = 1, 2, OR 3 THESE ARE THE RADIAL, CIRCUMFERENTIAL, AND AXIAL COORDINATES RESPECTIVELY IN A POLAR CYLINDRICAL SYSTEM. THE CIRCUMFERENTIAL ANGLE MUST BE EXPRESSED IN DEGREES AND BE MEASURED FROM THE Y, Z, OR X AXIS RESPECTIVELY ACCORDING TO WHETHER NS IS EQUAL TO 1, 2, OR 3. IF THE POINT IN QUESTION IS INTERIOR TO THE WET SURFACE OR IS NOT USED IN THE DEFINITION OF THE FLUID MESH THE COORDINATES THEMSELVES ARE NOT REQUIRED
NEL	I	GENERAL FLUID ELEMENT INDEX WHICH RUNS FROM 1 TO NGEN IN SEQUENTIAL ORDER
NC	I	NUMBER OF CORNER POINTS OF GENERAL FLUID ELEMENT, CURRENTLY RESTRICTED TO THE VALUES 3 OR 4. SEE FLUID ELEMENT LIBRARY. THE CORNER POINTS WILL USUALLY PARTICIPATE IN THE FLUID-STRUCTURE TRANSFORMATION
NN	I	NUMBER OF ADDITIONAL STRUCTURAL POINTS ASSOCIATED WITH A PARTICULAR GENERAL FLUID ELEMENT, CURRENTLY HAVING PERMISSIBLE VALUES OF 0, 1, 2, 3, AND 5 IF KTRN = 0 (SEE BELOW AND FLUID ELEMENT LIBRARY). IF KTRN IS NOT EQUAL TO ZERO THEN IT MAY HAVE ANY VALUE UP TO 12 FOR RECTANGLES AND 13 FOR TRIANGLES. THESE ADDITIONAL POINTS

ALWAYS PARTICIPATE IN THE FLUID-STRUCTURE TRANSFORMATION. IT IS EXTREMELY IMPORTANT TO THE UNDERWATER SHOCK ANALYSIS THAT ALL WETTED STRUCTURAL NODES LOCATED WITHIN AND ON THE BORDERS OF THE FLUID ELEMENT BE INCLUDED IN NN EVEN IF THE CASE KTRN NOT EQUAL TO ZERO MUST BE INVOKED

KURV I — FLUID ELEMENT CURVATURE FLAG. ACCEPTABLE VALUES ARE:

- 0 - FLAT ELEMENT
- 1 - CURVED ELEMENT, CODE WILL DETERMINE AVERAGE CURVATURE OF ELEMENT FROM NEIGHBOR POINT LOCATIONS. DO NOT USE THIS OPTION IF NN = 0
- 2 - CURVED ELEMENT, USER MUST INPUT PRINCIPLE RADII OF CURVATURE. IF EITHER RADIUS IS SET TO 10000 OR GREATER THEN ITS ASSOCIATED CURVATURE WILL BE SET TO ZERO

KTRN I — SHOULD HAVE THE VALUE OF ZERO UNDER NORMAL CIRCUMSTANCES WHEN THE FLUID-STRUCTURE TRANSFORMATION COEFFICIENTS ARE COMPUTED BY THE CODE. IF KTRN IS NONZERO THEN THESE COEFFICIENTS ARE DETERMINED BY HAND FOR THE ELEMENT IN QUESTION AND MUST BE READ AS INPUT DATA. THIS MUST BE DONE IF THE ELEMENT DOES NOT FIT ANY OF THE STANDARD PATTERNS IN THE FLUID ELEMENT LIBRARY. A DISCUSSION OF HOW TO DO THIS IN AN APPROXIMATE FASHION IS GIVEN BELOW (SEE TRAN)

NODE I — NODE POINT NUMBERS OF FLUID ELEMENT CORNER POINTS TAKEN IN COUNTER CLOCKWISE DIRECTION. IN GENERAL THE SIDE DEFINED BY THE FIRST TWO CORNER POINTS SHOULD BE ROUGHLY ORIENTED IN THE DIRECTION OF ONE OF THE PRINCIPAL AXES OF THE ELEMENT SO AS TO KEEP THE PRODUCT OF INERTIA OF THE ELEMENT SMALL RELATIVE TO ITS PRINCIPAL MOMENTS OF INERTIA. IF THIS RULE IS NOT FOLLOWED IT IS POSSIBLE THAT THE FLUID - STRUCTURE TRANSFORMATION ARRAY FOR THE ELEMENT WILL BE ILL CONDITIONED. ASSIGN A NEGATIVE VALUE TO ANY NODE NUMBER THAT IS NOT PART OF THE STRUCTURAL FINITE ELEMENT MODEL SO THEY WILL NOT PARTICIPATE IN THE FLUID - STRUCTURE TRANSFORMATION. AT PRESENT SUCH POINTS CAN ONLY BE USED IN CONJUNCTION WITH 6 - NODE QUADRILATERALS. SEE FLUID ELEMENT LIBRARY

ITEM I — NODE POINT NUMBERS OF FLUID ELEMENT NEIGHBOR POINTS AGAIN TAKEN IN COUNTER CLOCKWISE ORDER STARTING FROM FIRST CORNER

		POINT. ANY INTERIOR POINTS MUST APPEAR LAST. SEE FLUID ELEMENT LIBRARY
RAD1	E,F	RADIUS OF CURVATURE OF FLUID ELEMENT IN DIRECTION FROM FIRST CORNER POINT TO SECOND CORNER POINT
RAD2	E,F	RADIUS OF CURVATURE OF FLUID ELEMENT IN DIRECTION PERPENDICULAR TO SIDE JOINING FIRST CORNER POINT AND SECOND CORNER POINT
ECCEN	E,F	PROVIDES A MEANS OF SHIFTING THE FLUID CONTROL POINT OUT OF THE PLANE OF THE STRUCTURAL NODE POINTS TO ALLOW FOR A FINITE PLATE OR SHELL THICKNESS. GENERALLY USED TO DEFINE SEPARATE FLUID ELEMENTS ON OPPOSITE SIDES OF A SURFACE. A POSITIVE VALUE INDICATES AN ECCENTRICITY IN THE DIRECTION OF THE OUTWARD UNIT NORMAL VECTOR. THIS OPTION MAY BE USED ONLY WITH KURV EQUAL TO 2 AT THIS TIME. WHEN DEFINING TWO FLUID ELEMENTS ON OPPOSITE SIDES OF A SURFACE THE FIRST AND SECOND NODE NUMBERS INPUT FOR ONE ELEMENT (SEE NODE) SHOULD BE THE SECOND AND FIRST NODE NUMBERS RESPECTIVELY FOR THE OTHER ELEMENT. IN THIS WAY THE LOCAL COORDINATE SYSTEM FOR EACH ELEMENT IS REFERRED TO THE SAME BASELINE THUS PRESERVING A DESIRED SYMMETRY IN THE CALCULATIONS
TRAN	E,F	HAND DETERMINED COEFFICIENTS OF THE FLUID-STRUCTURE TRANSFOMATION ARRAY THAT MUST BE READ AS INPUT DATA. THE MOST CONVENIENT WAY OF GENERATING THESE COEFFICIENTS IS TO FIRST BREAK THE ELEMENT INTO SUB-ELEMENTS SUCH AS TRIANGLES OR RECTANGLES SUCH THAT EVERY STRUCTURAL NODE IS A CORNER POINT FOR ONE OR MORE SUB-ELEMENTS.THE WEIGHTING COEFFICIENTS FOR TRIANGLES AND RECTANGLES ARE ONE-THIRD AND ONE-FOURTH RESPECTIVELY AND REPRESENT THE PERCENTAGE OF FLUID PRESSURE FORCE ON THE SUB-ELEMENT THAT IS TRANSMITTED TO ANY PARTICULAR CORNER POINT. THE FLUID-STRUCTURE TRANSFORMATION COEFFICIENT FOR ANY PARTICULAR STRUCTURAL NODE IS THEN EXPRESSED AS A SUM OVER THE SUB-ELEMENTS THAT COUPLE WITH THE NODE IN QUESTION. THE CONTRIBUTION TO THIS SUM FROM EACH SUB-ELEMENT IS JUST THE WEIGHTING COEFFICIENT OF THE SUB-ELEMENT TIMES THE AREA OF THE SUB-ELEMENT DIVIDED BY THE TOTAL AREA OF THE ELEMENT. NOTE THAT THE SUM OF THE FLUID-STRUCTURE TRANSFORMATION COEFFICIENTS FOR ANY FLUID ELEMENT MUST TOTAL UNITY. IF THE FLUID ELEMENT HAS A NON-STRUCTURAL POINT AS A CORNER FOLLOW

THE ABOVE PROCESS ANYWAY AND THEN ADD THE RESULTING COEFFICIENT FOR THE POINT IN QUESTION TO THAT FOR ITS NEAREST STRUCTURAL NODE. IF NECESSARY THE CONTRIBUTION COULD EVEN BE DIVIDED BETWEEN TWO OR MORE NODE POINTS. ONCE COMPUTED. THE ORDER OF INPUT TO THE CODE MUST AGREE WITH THE ORDER TAKEN FIRST BY THE CORNER POINT NODE NUMBERS (SEE NODE) AND THEN BY THE NEIGHBOR POINT NODE NUMBERS (SEE ITEM) CONSECUTIVELY

NTCY I

NUMBER OF STRUCTURAL NODE POINTS THAT COUPLE WITH A CURVED RECTANGULAR FLUID ELEMENT WHICH IS TO BE AUTOMATICALLY FORMED FOR AN AXIAL SEGMENT OF A RIGHT CIRCULAR CYLINDRICAL SURFACE. AVAILABLE OPTIONS ARE:

- 2 - STRUCTURAL NODES WILL BE ON MIDPOINT OF CURVED SIDES
- 4 - STRUCTURAL NODES WILL BE AT CORNERS
- 6 - FLUID ELEMENT WILL OVERLAP TWO (2) STRUCTURAL ELEMENTS. VARIABLE KFUN BELOW ALSO REQUIRED IN THIS CASE
- 9 - FLUID ELEMENT WILL OVERLAP FOUR (4) STRUCTURAL ELEMENTS. TWO IN THE AXIAL DIRECTION AND TWO IN THE CIRCUMFERENTIAL DIRECTION

KFUN I

DESCRIBES MANNER IN WHICH A SIX NODE RECTANGULAR FLUID ELEMENT OVERLAYS TWO RECTANGULAR STRUCTURAL ELEMENTS. PERMISSIBLE VALUES ARE:

- 1 - CONFIGURATION CONSISTS OF TWO STRUCTURAL ELEMENTS IN AXIAL DIRECTION
- 2 - CONFIGURATION CONSISTS OF TWO STRUCTURAL ELEMENTS IN CIRCUMFERENTIAL DIRECTION

KROT I

IF KROT = 0 THE Z DIRECTION WILL BE TAKEN AS THE AXIS FOR AUTOMATICALLY GENERATED ELEMENTS OVER A CYLINDRICAL SURFACE. IF KROT IS NOT EQUAL TO ZERO A ROTATION OF AXES WILL BE PERFORMED (SEE CYLANG)

KARC I

A VALUE OF ZERO USED UNDER NORMAL CONDITIONS INDICATES THAT THE AREA ASSOCIATED WITH AUTOMATICALLY GENERATED CYLINDRICAL SURFACE ELEMENTS IS TO BE CALCULATED USING THE CHORD WHICH AGREES WITH WHAT MOST STRUCTURAL FINITE ELEMENT CODES ASSUME. A VALUE OTHER THAN ZERO WILL SPECIFY THAT THE ARC LENGTH IS TO BE USED INSTEAD. THE DIFFERENCE BETWEEN THESE TWO CASES IS GENERALLY VERY SMALL FOR ANY

		REASONABLE CIRCUMFERENTIAL SPACING OF THE ELEMENTS. THE LATTER CAN GENERATE A SLIGHTLY MORE ACCURATE FLUID MASS MATRIX HOWEVER THE FORMER CAN GIVE A SLIGHTLY BETTER STRUCTURAL RESPONSE CALCULATION
NCRC	I	NUMBER OF CIRCUMFERENTIAL GENERAL ELEMENTS TO BE FORMED AUTOMATICALLY FOR AN AXIAL SEGMENT OF A RIGHT CIRCULAR CYLINDRICAL SURFACE
NLAST	I	NUMBER OF LAST FLUID ELEMENT IN SURFACE MESH WHICH PRECEEDES THE INPUT FOR THIS AXIAL SEGMENT. NLAST CAN HAVE THE VALUE OF ZERO IF REQUIRED
NSTART	I	NUMBER OF STRUCTURAL GRID OR NODE POINT AT BOTTOM LEFT HAND CORNER OF THE FIRST OF THIS SET OF CIRCUMFERENTIAL GENERAL FLUID ELEMENTS. IF NTCY = 2 THIS IS THE NODE AT THE MIDPOINT OF THE LEFT HAND SIDE
NDAX1	I	INCREMENT TO BE APPLIED TO NSTART IN DESIGNATING THE NUMBER OF THE CORRESPONDING STRUCTURAL NODE AT THE FIRST ROW OF CIRCUMFERENTIAL STRUCTURAL NODES TO THE RIGHT OF NSTART IN THE AXIAL DIRECTION
NDCR	I	INCREMENT TO BE APPLIED TO NSTART IN DESIGNATING THE NUMBER OF THE CORRESPONDING STRUCTURAL NODE AT THE FIRST ROW OF AXIAL STRUCTURAL NODES ABOVE NSTART IN THE CIRCUMFERENTIAL DIRECTION. FOR THE CASE NTCY = 6 WITH KFUN = 2. OR NTCY = 9 IT IS ASSUMED THAT NDCR IS THE SAME FOR EACH CIRCUMFERENTIAL INCREMENT
NDAX2	I	INCREMENT TO BE APPLIED TO NSTART + NDAX1 IN DESIGNATING THE NUMBER OF THE CORRESPONDING STRUCTURAL NODE AT THE SECOND ROW OF CIRCUMFERENTIAL STRUCTURAL NODES TO THE RIGHT OF NSTART IN THE AXIAL DIRECTION. THIS CASE IS CHARACTERIZED BY NTCY = 6 WITH KFUN = 1. OR NTCY = 9. OTHERWISE NDAX2 CAN BE SET TO ZERO
RAD	E,F	RADIUS OF CIRCULAR CYLINDRICAL SURFACE
AXL1	E,F	AXIAL COORDINATE OF THE FIRST ROW OF STRUCTURAL NODES IN THE CIRCUMFERENTIAL DIRECTION THAT COUPLE WITH A PARTICULAR SET OF CYLINDRICAL SURFACE GENERAL ELEMENTS. THIS ROW WILL FORM THE LEFT AXIAL BOUNDARY OF THE SET OF FLUID ELEMENTS
AXL2	E,F	AXIAL COORDINATE OF THE SECOND ROW OF STRUCTURAL NODES IN THE CIRCUMFERENTIAL

```
                                DIRECTION THAT COUPLE WITH A PARTICULAR
                                SET OF CYLINDRICAL SURFACE GENERAL
                                ELEMENTS. THIS ROW WILL FORM THE RIGHT
                                AXIAL BOUNDARY OF THE SET OF FLUID
                                ELEMENTS IF NTCY = 2, NTCY = 4, OR
                                NTCY = 6 WITH KFUN = 2. IF NTCY = 6 WITH
                                KFUN = 1, OR NTCY = 9 THIS ROW WILL LIE
                                WITHIN THE INTERIOR OF THE FLUID ELEMENT
                                AND THE STRUCTURAL NODES AT THIS LOCATION
                                WILL BE CONSIDERED AS NEIGHBOR POINTS IN
                                THE FLUID STRUCTURE TRANSFORMATION ARRAY

        THETS           E,F     ANGLE IN DEGREES THAT SPECIFIES THE
                                STARTING BOUNDARY FOR A SET OF GENERAL
                                ELEMENTS AROUND THE PARTIAL CIRCUMFERENCE
                                OF A RIGHT CIRCULAR CYLINDRICAL SURFACE.
                                THE X AXIS IS DEFINED AS ZERO AND THETS
                                CAN BE NEGATIVE IF DESIRED. THIS OPTION IS
                                IMPORTANT AS A DISCONTINUITY OF 360
                                DEGREES IN THE ANGULAR FUNCTION AT THE X
                                AXIS IS NOT PERMITTED

        THETF           E,F     ANGLE IN DEGREES THAT SPECIFIES THE
                                FINISHING BOUNDARY FOR A SET OF GENERAL
                                ELEMENTS AROUND THE PARTIAL CIRCUMFERENCE
                                OF A RIGHT CIRCULAR CYLINDRICAL SURFACE.
                                THE X AXIS IS DEFINED AS ZERO AND THETF
                                MUST BE POSITIVE. HOWEVER IT CAN BE EITHER
                                LARGER OR SMALLER THAN THE MAGNITUDE OF
                                THETS

        AXL3            E,F     AXIAL COORDINATE OF THE THIRD ROW OF
                                STRUCTURAL NODES IN THE CIRCUMFERENTIAL
                                DIRECTION THAT COUPLE WITH A PARTICULAR
                                SET OF CYLINDRICAL SURFACE GENERAL
                                ELEMENTS. IF AXL3 IS NON-ZERO THEN IT MUST
                                BE ALGEBRAICALLY GREATER THAN AXL2 AND
                                THIS ROW WILL THEN FORM THE RIGHT AXIAL
                                BOUNDARY OF THE SET OF FLUID ELEMENTS.
                                THIS CASE IS CHARACTERIZED BY NTCY = 6
                                WITH KFUN = 1, OR NTCY = 9

        CYLANG          E,F     EULERIAN ANGLES OF ROTATION USED TO ORIENT
                                THE AXIS OF CYLINDRICAL SURFACE GENERAL
                                ELEMENTS (SEE GEOANG FOR GENERAL
                                DEFINITION). IN THE FOLLOWING SPECIAL
                                CASES OF IMPORTANCE THE DESIRED AXIS IS
                                SHOWN IN THE LEFT HAND COLUMN WHILE THE
                                APPROPRIATE ANGLES ARE GIVEN TO THE RIGHT:

                                  X - 90, 180, 90      OR      0, +/-90, 0
                                  Y - 0, 90, 90        OR     +/-90, 0, 0
                                  Z - NO INPUT, SET KROT = 0

                                THIS OPTION IS NECESSARY WHEN USING STAGS
                                AS THE STRUCTURAL PROCESSOR IN ITS DEFAULT
                                MODE IN WHICH CASE IT USES THE X DIRECTION
                                AS THE CYLINDER AXIS
```

N1	I	GRID POINT NUMBER OF STRUCTURAL NODE THAT DEFINES THE BEGINNING OF A SURFACE OF REVOLUTION BRANCH OR SEGMENT
N2	I	GRID POINT NUMBER OF STRUCTURAL NODE THAT DEFINES THE END OF A SURFACE OF REVOLUTION BRANCH OR SEGMENT
R1	E,F	RADIUS TO WET SURFACE FROM AXIS OF SURFACE OF REVOLUTION ELEMENT AT STRUCTURAL GRID POINT DEFINING THE START OF A SOR BRANCH OR SEGMENT
R2	E,F	RADIUS TO WET SURFACE FROM AXIS OF SURFACE OF REVOLUTION ELEMENT AT STRUCTURAL GRID POINT DEFINING THE END OF A SOR BRANCH OR SEGMENT
NSET	I	NUMBER OF DATA CARDS REQUIRED TO DEFINE SURFACE OF REVOLUTION FLUID ELEMENTS ALONG THE LENGTH OF A PARTICULAR SOR BRANCH OR AXIS. IF NSET = 1 IT IS ASSUMED THAT THE PHYSICAL CONFIGURATION OF THE SOR BRANCH IS AS DESCRIBED BELOW UNDER ISEG
N3	I	GRID POINT NUMBER OF STRUCTURAL NODE THAT DEFINES THE AXIS OF THE SURFACE OF REVOLUTION BRANCH IN CONJUNCTION WITH N1 IF N2 = N1. THIS CASE CORRESPONDS TO A DISC
ISEG	I	NUMBER OF SURFACE OF REVOLUTION ELEMENTS THAT CAN BE DEFINED BETWEEN TWO AXIAL STATIONS SUCH THAT THE RADIUS OF THE SURFACE VARIES LINEARLY ALONG THE LENGTH AND THAT EVERY PAIR OF INTERMEDIATE ADJACENT STRUCTURAL NODE NUMBERS DIFFER BY A COMMON INCREMENTAL VALUE. THIS NEED NOT IMPLY EQUAL AXIAL SPACING OF THE SOR ELEMENTS AS THE STRUCTURAL NODES MAY NOT NECESSARILY BE EQUALLY SPACED ALONG THE AXIS
NUMCHG	I	NUMBER OF STRUCTURAL GRID POINTS THAT MUST BE RENUMBERED IN THE FLUID-STRUCTURE TRANSFORMATION DATA
NODOLD	I	STRUCTURAL GRID POINT NUMBER THAT IS TO BE CHANGED TO NODNEW IN THE FLUID-STRUCTURE TRANSFORMATION DATA
NODNEW	I	NEW STRUCTURAL GRID POINT NUMBER ASSIGNED TO FLUID-STRUCTURE TRANSFORMATION DATA IN PLACE OF NODOLD. THIS GRID POINT MUST ALREADY BE PART OF THE STRUCTURAL NODE GLOBAL COORDINATE DATA INPUT FROM CARDS AND/OR PERMANENT FILE

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

              I N P U T     D A T A     C A R D     D E C K

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

      ALL INPUT DATA EXCEPT ALPHANUMERIC DATA MUST BE RIGHT JUSTIFIED
      IN EIGHT (8) COLUMN FIELDS WHICH CAN OCCUPY THE ENTIRE CARD.
      ALPHANUMERIC DATA MUST BE LEFT JUSTIFIED IN TWENTY (20) COLUMN
      FIELDS. FILE NAME PLUS QUALIFIER IS CURRENTLY RESTRICTED TO
      EIGHTEEN (18) CHARACTERS FOR UNIVAC OPERATION WHILE NINETEEN (19)
      CHARACTERS MAY BE USED FOR CDC OPERATION

      NOTE THAT THERE IS A DESCRIPTIVE ENTRY IN THE FIRST FIELD OF SOME
      INPUT CARDS AND THAT THE DATA FOR THAT CARD ACTUALLY BEGINS IN THE
      SECOND FIELD. THIS OCCURS IN SUBROUTINES READST, GENELM, CYLGEO
      AND SORINP IN WHICH THE DESCRIPTOR IS GRID, GEN, CYL, AND SOR
      RESPECTIVELY. THIS PRACTICE IS A RESULT OF CHOOSING THE 'GRID'
      CARDS TO BE IDENTICAL TO THE INPUT TO NASTRAN FOR CONVENIENCE IN
      INTERFACING WITH THAT CODE. THE 'GEN', 'CYL' AND 'SOR' CARDS HAVE
      NOTHING TO DO WITH NASTRAN AND THE USAGE OF SUCH LABELS HERE IS
      FOR IDENTIFICATION ONLY

      GENERAL PROBLEM DEFINITION (SUBROUTINE AMINPT):
      -----------------------------------------------

      72 COLUMN ALPHANUMERIC TITLE
      NSTRC   NSTRF   NGEN    NBRA    NCYL

      IF NBRA NOT = 0 INCLUDE THE FOLLOWING THREE CARDS

      NHAS    NHAF    NHAI    NFUN    ITRG
      NSEG(I), I=1,NBRA
      NCIR(I), I=1,NBRA

      RHO     CEE     DAA2
      PRTGMT  PRTTRN  PRTAMF  CALCAM  PRTCOE
      EIGMAF  TWODIM  HAFMOD  QUAMOD
      PCHCDS  NASTAM  STOMAS  STOINV
      FRWTFL  FRWTGE  FRWTGR  FRESUR
      RENUMB  STOGMT  ROTGEO  ROTQUA
      FLUNAM              GEONAM              GRONAM              DAANAM

      IF EIGMAF = .TRUE. INCLUDE THE FOLLOWING CARD

      NVEC

      IF TWODIM = .TRUE. INCLUDE THE FOLLOWING TWO CARDS

      NUMZ
      ZLEN

      IF QUAMOD = .TRUE. INCLUDE THE FOLLOWING CARD

      CQ(I), I=1,4

      IF HAFMOD = .TRUE. INCLUDE THE FOLLOWING TWO CARDS
```

```
CQ(I), I=1,2
DEPTH   CXFS    CYFS    CZFS

IF FRESUR = .TRUE. INCLUDE THE FOLLOWING TWO CARDS

DEPTH   CXFS    CYFS    CZFS
PATM    GRAVAC

IF ROTGEO = .TRUE. INCLUDE THE FOLLOWING CARD

GEOANG(I), I=1,3

IF ROTQUA = .TRUE. INCLUDE THE FOLLOWING CARD

QUAANG(I), I=1,3

IF NCYL NOT = 0 READ THE FOLLOWING CARD

NSHIFT

STRUCTURAL NODE COORDINATES (SUBROUTINE READST):
-----------------------------------------------

IF NSTRC NOT = 0 INCLUDE THE FOLLOWING CARDS

GRID    NSEQ    NS      XC      YC      ZC      )
         .       .       .       .       .      )   TOTAL = NSTRC
         .       .       .       .       .      )

GENERAL ELEMENT DEFINITION (SUBROUTINE GENELM):
----------------------------------------------

IF NGEN NOT = 0 READ THE FOLLOWING CARDS

GEN     NEL     NC      NN      KURV    KTRN    )
        NODE(I), I=1,NC                         )
        ITEM(I), I=1,NN                         )
                                                )
IF KURV = 2 READ THE FOLLOWING CARD             )   TOTAL NUMBER OF
                                                )
        RAD1    RAD2    ECCEN                   )   SETS = NGEN
                                                )
IF KTRN NOT = 0 READ THE FOLLOWING CARD         )
                                                )
        TRAN(I), I=1,NC+NN                      )

CYLINDRICAL SURFACE GENERAL ELEMENTS (SUBROUTINE CYLGEO):
--------------------------------------------------------

IF NCYL NOT = 0 READ THE FOLLOWING CARDS FOR EACH AXIAL SEGMENT

CYL     NTCY    KFUN    KROT    KARC
        NCRC    NLAST   NSTART  NDAX1   NDCR    NDAX2
        RAD     AXL1    AXL2    THETS   THETF   AXL3

IF KROT NOT = 0 READ THE FOLLOWING CARD

```

```
          CYLANG(I), I=1,3

          SURFACE-OF-REVOLUTION ELEMENT DEFINITION (SUBROUTINE SORINP):
          -------------------------------------------------------------

          IF NBRA NOT = 0 READ THE FOLLOWING CARDS FOR EACH SOR BRANCH

          SOR     N1      N2      R1      R2      NSET

          IF N1 = N2 READ THE FOLLOWING CARD

                  N3

          IF NSET = 1 OMIT THE FOLLOWING CARD

                  N1      N2      R1      R2      ISEG   )
                  .       .       .       .       .      )   TOTAL = NSET
                  .       .       .       .       .      )

          STRUCTURAL NODE RENUMBERING (SUBROUTINE AMGEOM):
          ------------------------------------------------

          IF RENUMB = .TRUE. READ THE FOLLOWING CARDS

                  NUMCHG
                  NODOLD  NODNEW     )
                    .       .        )   TOTAL = NUMCHG
                    .       .        )
```

```
*****************************************************

          F L U I D    E L E M E N T    L I B R A R Y

*****************************************************
```

THE CORNER POINTS OF EACH OF THE ELEMENT TYPES SHOWN BELOW ARE ASSUMED TO LIE IN THE SAME PLANE AND THE DIRECTION OF THE UNIT NORMAL VECTOR IS TAKEN TO BE POSITIVE AS COMING UP FROM THE PAGE AND OUT INTO THE FLUID REGION. THE VIEWER IS THUS PLACED IN THE SAME RELATIVE POSITION AS A SCUBA DIVER GAZING AT THE SIDE OF A SUNKEN TREASURE SHIP. THE NODE ORDER FOR INPUT MUST ALWAYS BE IN THE COUNTERCLOCKWISE DIRECTION AS SHOWN BECAUSE THE RIGHT HAND RULE IS USED IN THE CODE TO DETERMINE THE POSITIVE OUTWARD DIRECTION. NOTE THAT CORNER POINTS ARE TAKEN FIRST. THEN ANY OTHER POINTS WHICH MAY BE INVOLVED IN THE FLUID-STRUCTURE TRANSFORMATION FOLLOW. YOU MAY PLAY CONNECT-THE-DOTS WITH YOUR PENCIL TO MAKE THE FIGURES MORE LEGIBLE IF YOU WISH

```
                                               3
BASIC FLUID ELEMENT CONFIGURATIONS:          .  .
                                           .     .
          3                              4        .
         .  .                           .          .
        .     .                        . GENERAL    .
       .        .                     .              .
      .  TRIANGLE .                  . QUADRILATERAL  .
     .               .              .                  .
    1..................2           1....................2

BASIC FLUID ELEMENT CONFIGURATIONS    4
WITH ADDITIONAL TRANSFORMATION       .   .
POINTS:                             .       6
                                   .           .
                                  .        .      .
                                 .                   .
          4...3                 .         .   GENERAL   .
               .               .  6-NODE                   3
         .      .             .          .  QUADRILATERAL  .
          6-NODE .           .                             .
        6         .         1...........5..................2
           .       .
       .      .     .
                 .   .             4
      .    GENERAL  . .               .
                       5          .      .
     .  QUADRILATERAL   .                   .
                         .       .             7
    1.....................2                   .   .
                                .   9-NODE   .       3
                                            .         .
                               8...........9...........6
                                          .             .
                              .          .   GENERAL     .
                                        .                 .
                             .         .   QUADRILATERAL   .
                                      .                     .
                            1........5.......................2
```

```
       3                                      3
         .                                   .  .
     .     .                                .
              .                            .     .
   .  4-NODE    .                         .    5
                  .                      .
   .  TRIANGLE      .                   .        .
                      .                .
  .          4          .             .  5-NODE    .
                          .          .
1.........................2         .   TRIANGLE    .
                                   .
                3                 .       4          .
              .   .              .
             .     .            1....................2
            .        .
           .    6      .
          .             .
         .                .
        .                  .
       .       6-NODE        .
      .                  5     .
     .        TRIANGLE           .
    .                              .
   .           4                     .
  .                                    .
1.........................................2
```

The following discussion is provided as an aid to user understanding of the sample output that is included here.

The first item needing explanation is the block subdivision table. During construction of the mass matrix the code must determine whether a particular fluid DOF pertains to a GEN (includes both GEN and CYL elements) or SOR element. In the latter case, it must also store the branch or axis of the element, its harmonic, and also whether that DOF corresponds to a cosine or sine function. DOF with similar characteristics are naturally kept together in the same block. When the mass matrix is automatically processed in an out of core mode GEN elements are also partitioned into blocks for computational convenience.

The parameters appearing in the block subdivision table are:

ISUB - block number

ITYP - GEN or SOR

IBEG - first row of block

IROW - number of rows in block

IBRA - SOR branch or axis

IHAR - harmonic number

IFUN - COS or SIN

Next, the terms appearing under "Fluid Mesh Geometric Arrays" are defined as:

NCOR - number of corner points for a particular fluid element

X,Y,Z - global cartesian coordinates of the fluid element centroidal control point

NX,NY,NZ - components of the outward unit normal vector for the fluid element

NTRA - number of structural node points that are coupled to a particular fluid element for the purpose of force application

A00,A20,A11,A02 - area and moments and product of inertia of fluid element. Used internally for construction of the fluid mass matrix and of the fluid-structure transformation coefficients for general elements. For SOR elements, these values are for the sub-elements.

BII,CII - diagonal terms of B and C matrices used for the construction of fluid mass matrix (see [14])

When SOR elements are included in the fluid mesh the following new terms will appear in the output:

NSOR - number of SOR element

NFLU - DOF in fluid mass matrix

RAD - radius of fluid element control point from axis of revolution

NCIR - number of integration points or sub-elements used in circumferential direction

Local Fluid-Structure Transformation Coefficients appear next. This is a summary that indicates which structural nodes couple with a particular fluid control point and the weighting factor for each. The weighting factors must always sum to unity for any fluid control point.

The generalized areas that follow are simply A00 for GEN elements. For SOR elements with IHAR = 0 they are A00*NCIR; for all other SOR elements they become .5*A00*NCIR.

The eigenvalues and eigenvectors that follow the listing of the added mass matrix correspond to the "Fluid Boundary Mode" problem [14]. For the infinite cylindrical shell problem presented here, the exact eigenvalues should behave as 1/n with corresponding modes cos $n\theta$ and sin $n\theta$. The first eigenvalue listed, 0.11831+04, is an approximation to ∞ for n=0 and it can be seen that the subsequent eigenvalues are relatively well behaved.

If a table labeled "SUMMARY OF I-O ACTIVITY" appears in the output, this indicates that automatic out-of-core processing has taken place. In such a case the "Fluid Boundary Mode" problem is not solved and its diagnostic characteristics are unavailable to the user. If there are any serious errors in the fluid mesh geometry that have remained undetected through the generation of the mass matrix these may show up in the construction of the matrix $\underset{\sim}{D}_{fl}$ [see Eq. (2.6)], i.e., the occurrence of factorization errors for the elements in question.

```
      FLUMAS RUN FOR INFINITE CYLINDER SIMULATION
               0         0         0         0        36
              1.        1.         5
               T         T         T         T         F
               T         T         F         F
               F         F         F         T
               F         F         F         F
               F         T         F         F
                                CYL*GEOM                                      CYL*DAAM
              36
             500
             175
               0
      CYL                2         0         0         0
                        36         0         1         1         2
                        1.    -.0875     .0875       -5.      355.

@XQT
```

@ADD.P CYLFLUDAT

FLUMAS RUN FOR INFINITE CYLINDER SIMULATION

MAXIMUM FLUID NODES = 69

SCRATCH ALLOCATION - 10000

FLUID MASS DENSITY = .10000000+01

FLUID SOUND SPEED = .10000000+01

DAA2 SCALAR FACTOR = .50000000+00

USER OPTIONS FOR THIS RUN:

PRTGMT	PRTTRN	PRTAMF	CALCAM	PRTCOE
T	T	T	T	F
EIGMAF	TWODIM	HAFMOD	QUAMOD	
T	T	F	F	
PCHCOS	HASTAM	STOMAS	STOINV	
F	F	F	F	
FRNTFL	FRWTGE	FRWTGR	FRESUR	
F	F	F	F	
RENUMB	STOGMT	ROTGEO	ROTQUA	
F	T	F	F	

FLUID MASS MATRIX BLOCK SUBDIVISION PARAMETERS:

ISUB	ITYP	IBEG	IROW	IBRA	IHAR	IFUN
1	GEN	1	30			

FLUID MESH GEOMETRIC ARRAYS:

N	NCOR	X		Z	NX	NY	NZ
1	4	.10000000+01	.00000000	.00000000	.10000000+01	.00000000	.00000000
2	4	.98480775+00	.17364818+00	.00000000	.98480775+00	.17364818+00	.00000000
3	4	.93969262+00	.34202015+00	.00000000	.93969262+00	.34202015+00	.00000000
4	4	.86602540+00	.50000001+00	.00000000	.86602540+00	.50000001+00	.00000000
5	4	.76604443+00	.64278762+00	.00000000	.76604443+00	.64278762+00	.00000000
6	4	.64278760+00	.76604445+00	.00000000	.64278760+00	.76604445+00	.00000000
7	4	.49999999+00	.86602541+00	.00000000	.49999999+00	.86602541+00	.00000000
8	4	.34202012+00	.93969263+00	.00000000	.34202012+00	.93969263+00	.00000000

9	4	.17364815+00	.98480776+00	.00000000	.17364815+00	.98480776+00	.00000000
10	4	-.28810229-07	.10000000+01	.00000000	-.28810229-07	.10000000+01	.00000000
11	4	-.17364822+00	.98480774+00	.00000000	-.17364822+00	.98480774+00	.00000000
12	4	-.34202018+00	.93969261+00	.00000000	-.34202018+00	.93969261+00	.00000000
13	4	-.50000002+00	.86602539+00	.00000000	-.50000002+00	.86602539+00	.00000000
14	4	-.64278765+00	.76604441+00	.00000000	-.64278765+00	.76604441+00	.00000000
15	4	-.76604448+00	.64278758+00	.00000000	-.76604448+00	.64278758+00	.00000000
16	4	-.86602543+00	.49999996+00	.00000000	-.86602543+00	.49999996+00	.00000000
17	4	-.93969265+00	.34202008+00	.00000000	-.93969265+00	.34202008+00	.00000000
18	4	-.98480777+00	.17364812+00	.00000000	-.98480777+00	.17364812+00	.00000000
19	4	-.10000000+01	-.57620458-07	.00000000	-.10000000+01	-.57620458-07	.00000000
20	4	-.98480774+00	-.17364823+00	.00000000	-.98480774+00	-.17364823+00	.00000000
21	4	-.93969259+00	-.34202022+00	.00000000	-.93969259+00	-.34202022+00	.00000000
22	4	-.86602537+00	-.50000006+00	.00000000	-.86602537+00	-.50000006+00	.00000000
23	4	-.76604440+00	-.64278766+00	.00000000	-.76604440+00	-.64278766+00	.00000000
24	4	-.64278754+00	-.76604450+00	.00000000	-.64278754+00	-.76604450+00	.00000000
25	4	-.49999995+00	-.86602543+00	.00000000	-.49999995+00	-.86602543+00	.00000000
26	4	-.34202007+00	-.93969265+00	.00000000	-.34202007+00	-.93969265+00	.00000000
27	4	-.17364807+00	-.98480777+00	.00000000	-.17364807+00	-.98480777+00	.00000000
28	4	.71529525-07	-.10000000+01	.00000000	.71529525-07	-.10000000+01	.00000000
29	4	.17364827+00	-.98480774+00	.00000000	.17364827+00	-.98480774+00	.00000000
30	4	.34202026+00	-.93969256+00	.00000000	.34202026+00	-.93969256+00	.00000000
31	4	.50000007+00	-.86602536+00	.00000000	.50000007+00	-.86602536+00	.00000000
32	4	.64278769+00	-.76604437+00	.00000000	.64278769+00	-.76604437+00	.00000000
33	4	.76604453+00	-.64278751+00	.00000000	.76604453+00	-.64278751+00	.00000000
34	4	.86602546+00	-.49999991+00	.00000000	.86602546+00	-.49999991+00	.00000000
35	4	.93969266+00	-.34202003+00	.00000000	.93969266+00	-.34202003+00	.00000000
36	4	.98480777+00	-.17364809+00	.00000000	.98480777+00	-.17364809+00	.00000000

N	NTRA	A00	A20	A11	A02	B11	C11
1	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
2	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
3	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
4	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
5	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
6	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
7	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
8	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217-01
9	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
10	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
11	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
12	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
13	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
14	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
15	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
16	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
17	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
18	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
19	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
20	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
21	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
22	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
23	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
24	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
25	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
26	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01

27	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
28	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
29	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
30	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
31	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
32	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
33	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
34	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
35	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01
36	2	.30504511-01	.77238069-04	-.30109248-12	.77850044-04	.61574592+00	.64371217+01

LOCAL FLUID-STRUCTURE TRANSFORMATION COEFFICIENTS:

NFLU	NSTR	
1	1	2
	.50000+00	.50000+00
2	3	4
	.50000+00	.50000+00
3	5	6
	.50000+00	.50000+00
4	7	8
	.50000+00	.50000+00
5	9	10
	.50000+00	.50000+00
6	11	12
	.50000+00	.50000+00
7	13	14
	.50000+00	.50000+00
8	15	16
	.50000+00	.50000+00
9	17	18
	.50000+00	.50000+00
10	19	20
	.50000+00	.50000+00
11	21	22
	.50000+00	.50000+00
12	23	24
	.50000+00	.50000+00
13	25	26
	.50000+00	.50000+00
14	27	28
	.50000+00	.50000+00
15	29	30
	.50000+00	.50000+00
16	31	32
	.50000+00	.50000+00
17	33	34
	.50000+00	.50000+00
18	35	36
	.50000+00	.50000+00
19	37	38
	.50000+00	.50000+00
20	39	40
	.50000+00	.50000+00
21	41	42
	.50000+00	.50000+00
22	43	44

```
          .50000+00   .50000+00
 23          45          46
          .50000+00   .50000+00
 24          47          48
          .50000+00   .50000+00
 25          49          50
          .50000+00   .50000+00
 26          51          52
          .50000+00   .50000+00
 27          53          54
          .50000+00   .50000+00
 28          55          56
          .50000+00   .50000+00
 29          57          58
          .50000+00   .50000+00
 30          59          60
          .50000+00   .50000+00
 31          61          62
          .50000+00   .50000+00
 32          63          64
          .50000+00   .50000+00
 33          65          66
          .50000+00   .50000+00
 34          67          68
          .50000+00   .50000+00
 35          69          70
          .50000+00   .50000+00
 36          71          72
          .50000+00   .50000+00

+++  @ ASG,UPR     CYL*GEOM.,            F/     4/TRK/    1024
+++  @ USE       2,CYL*GEOM.

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+          A U X I L I A R Y   S T O R A G E   T A B L E           +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                                  +
+LDI EDN(Q*FEN) IFN    FC OP SEC CDLOC   NEXT  LIMIT     READ WRITTEN +
+  2 CYL*GEOM    2     36 UPR28    36     36  65536         0     766 +
+                                                                  +
+                     1 ACTIVE DEVICES ( 0 FULL)                   +
+       0 TP-OPS,      13 WRITES,       0 READS,      766 WORDS XFD  +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

+++  @ FREE       CYL*GEOM.

   GENERALIZED FLUID AREAS:

          1          2          3          4          5          6          7          8          9         10
     .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01
         11         12         13         14         15         16         17         18         19         20
     .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01
         21         22         23         24         25         26         27         28         29         30
     .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01
         31         32         33         34         35         36
     .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01
```

ADDED MASS MATRIX IN FLUID COORDINATES:

	1	2	3	4	5	6	7	8	9	10
1	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01
2	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01
3	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01
4	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01
5	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01
6	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01
7	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01
8	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01
9	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01
10	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01
11	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01
12	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01
13	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01
14	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01
15	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01
16	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01
17	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01
18	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01
19	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01
20	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01
21	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01
22	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01
23	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01
24	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01
25	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01
26	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01
27	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01
28	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01
29	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01
30	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01
31	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01
32	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01
33	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01
34	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01
35	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01
36	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01

	11	12	13	14	15	16	17	18	19	20
1	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01
2	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01
3	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01
4	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01
5	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01
6	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01
7	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01
8	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01
9	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01
10	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01
11	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01
12	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01
13	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01
14	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01
15	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01
16	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01
17	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01
18	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10053+01	.10055+01	.10043+01

19	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01
20	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01
21	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01
22	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01
23	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01
24	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01
25	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01
26	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01
27	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01
28	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01
29	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01
30	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01
31	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01
32	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01
33	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01
34	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01
35	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01
36	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01
	21	22	23	24	25	26	27	28	29	30
1	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01
2	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01
3	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01
4	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01
5	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01
6	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01
7	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01
8	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01
9	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01
10	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01
11	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01
12	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01
13	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01
14	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01
15	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01
16	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01
17	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01
18	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01
19	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01
20	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01
21	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01
22	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01
23	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01
24	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01
25	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01
26	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01
27	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01
28	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01
29	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01
30	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01
31	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01
32	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01
33	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01
34	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01
35	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01
36	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01
	31	32	33	34	35	36				
1	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01				
2	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01	.10043+01				

3	.10020+01	.10022+01	.10025+01	.10028+01	.10031+01	.10036+01
4	.10019+01	.10020+01	.10022+01	.10025+01	.10026+01	.10031+01
5	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01	.10028+01
6	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01	.10025+01
7	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01	.10022+01
8	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01	.10020+01
9	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01	.10019+01
10	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01	.10018+01
11	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10016+01
12	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01
13	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01
14	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01
15	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01	.10014+01
16	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01	.10013+01
17	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01	.10013+01
18	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01	.10013+01
19	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01	.10013+01
20	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01	.10013+01
21	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01	.10014+01
22	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01	.10014+01
23	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01	.10015+01
24	.10022+01	.10020+01	.10019+01	.10018+01	.10016+01	.10015+01
25	.10025+01	10022+01	.10020+01	.10019+01	.10018+01	.10016+01
26	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01	.10018+01
27	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01	.10019+01
28	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01	.10020+01
29	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01	.10022+01
30	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01	.10025+01
31	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01	.10028+01
32	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01	.10031+01
33	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01	.10036+01
34	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01	.10043+01
35	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01	.10055+01
36	.10028+01	.10031+01	.10036+01	.10043+01	.10055+01	.10083+01

+++ @ ASG,T UNIT04. F4/ 4/TRK/ 256
+++ @ USE 4,UNIT04.

EIGENVALUES:

1	2	3	4	5	6	7	8	9	10
.11831+04	.99737+00	.99737+00	.49751+00	.49751+00	.33036+00	.33036+00	.24643+00	.24643+00	.19591+00
11	12	13	14	15	16	17	18	19	20
.19590+00	.16223+00	.16223+00	.13829+00	.13829+00	.12051+00	.12051+00	.10688+00	.10688+00	.96225-01
21	22	23	24	25	26	27	28	29	30
.96222-01	.87792-01	.87789-01	.81121-01	.81118-01	.75887-01	.75885-01	.71864-01	.71862-01	.68879-01
31	32	33	34	35	36				
.68978-01	.66819-01	.66816-01	.65605-01	.65599-01	.65202-01				

EIGENVECTORS:

	1	2	3	4	5	6	7	8	9	10
1	.95426+00	.12921+01	.33326+00	.13332+01	-.24375+00	-.13359+01	-.20162+00	.11436+01	.64405+00	-.12152+01
2	.95426+00	.13401+01	.10111+00	.13245+01	.22493+00	-.12528+01	.49247+00	.13367+01	-.26846+00	-.12309+01
3	.95426+00	.13474+01	-.13411+00	.11559+01	.63646+00	-.83387+00	.10548+01	.90427+00	-.10560+01	-.36643+00
4	.95426+00	.13137+01	-.36525+00	.84796+00	.10276+01	-.19157+00	.13344+01	.40728-01	-.13490+01	.75953+00
5	.95426+00	.12402+01	-.58530+00	.43777+00	.12648+01	.50200+00	.12564+01	-.82953+00	-.10109+01	.13428+01
6	.95426+00	.11290+01	-.78757+00	-.25241-01	.13495+01	.10611+01	.84185+00	-.13197+01	-.19965+00	.96677+00

7	.95426+00	[illegible]	-.96590+00	-.48590+00	.12714+01	.13359+01	.20168+00	-.11023+01	[illegible]	-.99923-01
8	.95426+00	.80799+00	-.11149+01	-.88663+00	.10399+01	.12527+01	-.49252+00	-.50707+00	.12797+01	-.10952+01
9	.95426+00	.60302+00	-.12300+01	-.11811+01	.68303+00	.83305+00	-.10548+01	.41144+00	.12557+01	-.13081+01
10	.95426+00	[illegible]	-.13077+01	-.13332+01	[illegible]	.19159+00	-.13344+01	[illegible]	.64409+00	[illegible]
11	.95426+00	[illegible]	-.13457+01	-.13244+01	[illegible]	-.50198+00	-.12564+01	[illegible]	-.26866+00	[illegible]
12	.95426+00	[illegible]	-.13428+01	-.11559+01	[illegible]	-.10611+01	-.84180+00	[illegible]	-.10560+01	[illegible]
13	.95426+00	[illegible]	-.12992+01	-.84800+00	[illegible]	-.13358+01	-.20170+00	[illegible]	-.13490+01	.11157+01
14	.95426+00	[illegible]	-.12160+01	[illegible]	[illegible]	-.12527+01	.49253+00	[illegible]	-.10109+01	[illegible]
15	.95426+00	[illegible]	-.10959+01	.25234-01	[illegible]	-.93390+00	.10548+01	[illegible]	[illegible]	[illegible]
16	.95426+00	[illegible]	-.94248+00	[illegible]	[illegible]	-.19166+00	.13344+01	-.11023+01	[illegible]	[illegible]
17	[illegible]	[illegible]	-.70043+00	[illegible]	[illegible]	.50199+00	.12561+01	-.50717+00	.12797+01	[illegible]
18	[illegible]	-.12046+01	-.55528+00	.11811+01	[illegible]	.10611+01	.84183+00	.41533+00	.12557+01	[illegible]
19	[illegible]	[illegible]	-.33326+00	.13332+01	[illegible]	.13359+01	.20167+00	.11435+01	.64411+00	[illegible]
20	[illegible]	-.13401+01	-.10111+00	.13244+01	.22492+00	.12527+01	-.49253+00	.13306+01	-.26887+00	[illegible]
21	.95426+00	[illegible]	.13411+00	.11559+01	[illegible]	.83389+00	-.10548+01	.90430+00	-.10560+01	[illegible]
22	[illegible]	[illegible]	.30525+00	.84801+00	.10276+01	.19162+00	-.13344+01	.48912-01	-.13491+01	[illegible]
23	.95426+00	[illegible]	.58530+00	.43780+00	.12646+01	-.50196+00	-.12564+01	-.82943+00	-.10109+01	-.13427+01
24	.95426+00	[illegible]	.78757+00	-.25197-01	.13495+01	-.10611+01	-.84183+00	-.13197+01	[illegible]	[illegible]
25	[illegible]	[illegible]	.96590+00	-.48517+00	.12714+01	-.13358+01	-.20168+00	-.11024+01	.70501+00	.99710-01
26	[illegible]	[illegible]	.11149+01	-.88661+00	[illegible]	-.12527+01	.49252+00	-.50724+00	.12798+01	.10950+01
27	.95426+00	-.60503+00	.12300+01	-.11811+01	[illegible]	-.83389+00	.10548+01	.41529+00	.12557+01	.13080+01
28	.95426+00	-.38058+00	.13077+01	-.13332+01	.24375+00	-.19168+00	.13344+01	.11435+01	.64407+00	.58655+00
29	.95426+00	[illegible]	.13457+01	-.13244+01	-.22492+00	.50191+00	.12564+01	.13367+01	-.26890+00	[illegible]
30	.95426+00	[illegible]	.13428+01	-.11559+01	-.65646+00	.10610+01	.84185+00	[illegible]	-.10561+01	[illegible]
31	.95426+00	[illegible]	.12992+01	-.84800+00	-.10276+01	.13358+01	.20167+00	.48947-01	-.13491+01	-.11157+01
32	[illegible]	.53203+00	.12160+01	-.43782+00	-.12648+01	.12527+01	-.49255+00	-.82947+00	-.10108+01	[illegible]
33	[illegible]	[illegible]	.10959+01	.25168-01	[illegible]	.83392+00	-.10548+01	[illegible]	[illegible]	[illegible]
34	[illegible]	[illegible]	.94248+00	.48516+00	[illegible]	.19167+00	[illegible]	[illegible]	[illegible]	[illegible]
35	[illegible]	[illegible]	.70043+00	.88661+00	[illegible]	-.50191+00	-.12564+01	[illegible]	.12797+01	[illegible]
36	[illegible]	[illegible]	.55528+00	.11811+01	[illegible]	-.10610+01	-.64184+00	.41529+00	[illegible]	[illegible]

	11	12	13	14	15	16	17	18	19	20
1	[illegible]	.22263+00	.12308+01	-.12280+01	[illegible]	.45536+00	-.12703+01	-.30101+00	.13124+01	-.42718+00
2	[illegible]	.12637+01	.10947+01	-.94613+00	-.10456+01	.13304+01	.22761+00	.13147+01	.31405+00	-.11864+01
3	[illegible]	.10418+01	-.13598+00	.58076+00	[illegible]	.60503-02	.13497+01	.30377+00	-.13125+01	[illegible]
4	[illegible]	-.22203+00	-.12308+01	.13435+01	[illegible]	-.13281+01	.24097+00	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	-.10947+01	.33808+00	[illegible]	-.46715+00	-.12659+01	[illegible]	[illegible]	-.11507+01
6	[illegible]	[illegible]	.13603+00	-.11121+01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	-.13470+01	[illegible]	.12307+01	-.10989+01	[illegible]	.67212+00	.10295+01	.30373+00	[illegible]	.13224+01
8	-.80158+00	.12637+01	.10947+01	.36046+00	-.12615+01	-.86285+00	.10382+01	-.13146+01	-.31404+00	.35728-01
9	.31650+00	.10417+01	-.13596+00	.13455+01	.18924-01	-.11718+01	-.66900+00	-.30383+00	.13125+01	-.13348+01
10	.12085+01	-.22195+00	-.12307+01	.55987+00	[illegible]	.45582+00	-.12705+01	.13146+01	.31402+00	.42763+00
11	.12370+01	-.12637+01	-.10948+01	-.96244+00	.85288+00	.13301+01	[illegible]	.30377+00	-.13125+01	[illegible]
12	.33183+00	-.10417+01	.13593+00	-.12182+01	[illegible]	.62158-02	.13496+01	[illegible]	-.31403+00	[illegible]
13	-.74616+00	[illegible]	.12307+01	.12912+00	[illegible]	-.13279+01	.24100+00	[illegible]	.13125+01	[illegible]
14	-.13410+01	[illegible]	.10948+01	.13065+01	[illegible]	-.46731+00	-.12658+01	[illegible]	.31401+00	.11502+01
15	-.97786+00	.10418+01	-.13586+00	.76463+00	[illegible]	.11655+01	-.66061+00	.30375+00	-.13125+01	[illegible]
16	.83941-01	-.22203+00	-.12307+01	-.78347+00	.10210+01	.87216+00	.10294+01	-.13147+01	[illegible]	-.13223+01
17	.10857+01	[illegible]	-.10949+01	-.13004+01	-.47912+00	-.86271+00	.10380+01	-.30404+00	.13125+01	-.36303-01
18	.13119+01	-.10418+01	.13590+00	-.10618+00	-.13494+01	-.11717+01	[illegible]	.13149+01	[illegible]	[illegible]
19	.60080+00	[illegible]	.12308+01	.12278+01	[illegible]	.45576+00	-.12703+01	.30409+00	[illegible]	[illegible]
20	-.53951+00	.12639+01	.10949+01	.94600+00	[illegible]	.13301+01	.22774+00	-.13148+01	[illegible]	-.11865+01
21	[illegible]	[illegible]	-.13592+00	-.58065+00	[illegible]	.61381-02	[illegible]	[illegible]	[illegible]	.83933+00
22	[illegible]	-.22209+00	-.12308+01	-.13433+01	[illegible]	-.13278+01	[illegible]	.13150+01	.31399+00	[illegible]
23	-.15124+00	[illegible]	-.10949+01	-.33810+00	-.13321+01	-.46750+00	-.12658+01	.30421+00	-.13125+01	-.11499+01
24	.93007+00	[illegible]	.13590+00	.11119+01	-.65840+00	.11655+01	-.68053+00	[illegible]	-.31401+00	-.49569+00
25	.13469+01	.22206+00	.12306+01	.10988+01	.98183+00	.87228+00	.10294+01	-.30435+00	.13125+01	.13221+01
26	.80147+00	.12639+01	.10949+01	-.36036+00	.12616+01	-.86243+00	.10381+01	[illegible]	.31403+00	.36546-01
27	-.31654+00	.10419+01	-.13568+00	-.13453+01	-.18918-01	-.11718+01	-.66892+00	.30442+00	-.13125+01	-.13348+01

28	-.12[illegible]+01	-.22[illegible]+00	-.12307+01	-.15993+00	-.12745+01	.45543+00	-.12704+01	-.13[illegible]+01	-.31452+0	.42680+00
29	-.12370+01	-.12639+01	-.10949+01	.96234+00	-.85255+00	.13300+01	.22770+00	-.30350+00	.13125+01	.11867+01
30	-.38175+00	-.10119+01	.13586+00	.12182+01	.6[illegible]113+00	.65795-02	.13495+01	.13150+01	.31405+0[illegible]	-.83[illegible]0+00
31	.74616+00	.22[illegible]+00	.12308+01	-.12962+00	[illegible]	-.13977+01	.24092+00	[illegible]	-.13124+0[illegible]	-.[illegible]27+00
32	.13410+01	.1[illegible]38+01	.10949+01	-.13064+01	.21572+00	-.46786+00	-.12658+01	-.13151+01	-.31403+0[illegible]	.11590+01
33	.97[illegible]+00	.1[illegible]+01	-.13590+00	-.[illegible]473+00	-.11742+0[illegible]	.11654+01	-.68078+00	-.33426+00	.131[illegible]4+01	.49[illegible]9+00
34	-.83[illegible]-01	-.22167+00	-.12307+01	.78335+00	-.10216+01	.87263+00	.10205+01	.13150+01	.31392+0[illegible]	-.13221+01
35	-.10857+01	-.1[illegible]58+01	-.10946+01	.13006+01	.47945+00	-.86231+00	.10380+01	.31427+00	-.13124+01	-.[illegible]63-01
36	-.13118+01	-.13120+01	.13583+00	.10632+00	.13496+01	-.11722+01	-.66010+00	-.13151+01	-.31404+00	.13348+01
	21	22	23	24	25	26	27	28	29	30
1	.12778+01	.41974+00	.12604+01	-.65183+00	.11742+01	.12174+01	.57433+00	-.52[illegible]6+00	-.12445+01	.63848+00
2	-.63[illegible]+00	.13613+01	-.86879+00	-.69693+00	-.11[illegible]2+01	-.23[illegible]2+00	-.13038+01	-.[illegible]19+00	.12656+01	.10996-01
3	-.10[illegible]	-.11361+01	-.67393+00	.13491+01	-.13149-01	-.78534+00	.11007+01	.11320+01	-.72262+00	-.70998+00
4	.10134+01	-.27730+00	.13296+01	-.65227+00	.11759+01	.13458+01	-.11089+00	-.13391+01	-.17882+00	.11888+01
5	.70178+00	.13360+01	-.23681+00	-.69707+00	-.11622+01	-.94494+00	-.95810+00	.91957+00	.59046+00	-.13491+01
6	-.12571+01	-.63692+00	-.11676+01	.13493+01	-.13500-01	-.13083+00	.13434+01	-.60673-01	-.13418+01	.11479+01
7	-.26518+00	-.99945+00	.10355+01	-.65224+00	.11757+01	.11150+01	-.76868+00	-.81287+00	.10097+01	-.63927+00
8	.13492+01	.12525+01	.45917+00	-.69716+00	-.11623+01	-.13000+01	-.35517+00	.13151+01	-.26947+00	-.40696-01
9	-.20343+00	.4[illegible]29-01	-.13496+01	.13494+01	-.13135-01	.55827+00	.12254+01	-.12019+01	-.62546+0[illegible]	.70976+00
10	-.127[illegible]+01	-.1[illegible]24+01	.46395+00	-.65250+00	.11753+01	.58229+00	-.12203+01	.52641+00	.12483+01	-.11887+01
11	.64763+00	.83332+00	.10323+01	-.69703+00	-.11621+01	-.13068+01	.34368+00	.39546+00	-.12872+01	.13491+01
12	.10536+01	.71243+00	-.11702+01	.13492+01	-.13148-01	.10976+01	.77845+00	-.11323+01	.72400+00	-.11496+01
13	-.10136+01	-.13207+01	-.23170+00	-.65214+00	.11753+01	-.10424+00	-.13414+01	.13394+01	.17784+00	.63923+00
14	-.70169+00	.19112+00	.13285+01	-.69727+00	-.11627+01	-.96371+00	.94970+00	-.91979+00	-.99611+00	.10790-01
15	.12574+01	.11899+01	-.67701+00	.13495+01	-.12311-01	.13432+01	.12368+00	.59862-01	.13481+01	-.70979+00
16	.26438+00	-.10050+01	-.86538+00	-.65220+00	.11749+01	-.75305+00	-.11068+01	.81277+00	-.10694+01	.11685+01
17	-.13493+01	-.59767+00	.12692+01	-.69721+00	-.11624+01	-.36209+00	.13022+01	-.13150+01	.28945+00	-.13487+01
18	.20359+00	.13490+01	-.30068-02	.13493+01	-.12614-01	.12284+01	-.56570+00	.12018+01	.62533+0	.11474+01
19	.12785+01	-.41998+00	-.12672+01	-.65215+00	.11750+01	-.12171+01	-.57489+00	-.52627+00	-.12460+01	-.63869+00
20	-.64772+00	-.10616+01	.86979+00	-.69725+00	-.11627+01	.33615+00	.13047+01	-.39556+00	.12869+01	-.41174-01
21	-.10534+01	.11460+01	.67229+00	.13495+01	-.12029-01	.78507+00	-.11023+01	.11324+01	-.72400+00	.71005+00
22	.10139+01	.27788+00	-.13298+01	-.65233+00	.11745+01	-.13456+01	.11227+00	-.13394+01	-.17736+0	-.11888+01
23	.70150+00	-.13362+01	.23765+00	-.69707+00	-.11623+01	.94494+00	.95827+00	.91971+00	.99541+00	.13440+01
24	-.12572+01	.63612+00	.11672+01	.13494+01	-.12169-01	.13071+00	-.13444+01	-.60702-01	-.13477+01	-.11477+01
25	-.26478+00	.90108+00	-.10360+01	-.65219+00	.11747+01	-.11129+01	.77027+00	-.81290+00	.10693+01	.63899+00
26	.13191+01	-.12524+01	-.45847+00	-.69721+00	-.11627+01	.12999+01	.35395+00	.13151+01	-.29055+00	.40954-01
27	-.20379+00	-.44429-01	.13497+01	.13494+01	-.11747-01	-.55820+00	-.12254+01	-.12020+01	-.62410+00	-.70994+00
28	-.12784+01	.12629+01	-.46497+00	-.65215+00	.11744+01	-.58237+00	.12215+01	.52638+00	.12469+01	.11867+01
29	.64793+00	-.83312+00	-.10314+01	-.69721+00	-.11626+01	.13069+01	-.34495+00	.39554+00	-.12865+01	-.13488+01
30	.10534+01	-.71290+00	.11704+01	.13493+01	-.11771-01	-.10978+01	-.77811+00	-.11324+01	.72449+00	.11475+01
31	-.10138+01	.13207+01	.23087+00	-.65209+00	.11745+01	.10442+00	.13455+01	.13395+01	.17636+00	-.63872+00
32	-.70113+00	-.19057+00	-.13283+01	-.69714+00	-.11628+01	.96363+00	-.95106+00	-.91982+00	-.99494+00	-.41130-01
33	.12571+01	-.11901+01	.67758+00	.13490+01	-.12024-01	-.13434+01	-.12236+00	.69648-01	.13465+01	.70996+00
34	.20451+00	.10046+01	.80474+00	-.65185+00	.11749+01	.76343+00	.11090+01	.81316+00	-.10712+01	-.11886+01
35	-.13489+01	.50299+00	-.12691+01	-.69705+00	-.11629+01	.36191+00	-.13033+01	-.13155+01	.29258+00	.13489+01
36	.20393+00	-.13486+01	.34075-02	.13488+01	-.11775-0[illegible]	-.12280+01	.56060+00	.12023+01	.62291+00	-.11477+01
	31	32	33	34	35	36				
1	.11743+01	-.48196+00	-.12552+01	.68621-01	-.13502+01	.96269+00				
2	-.13472+01	.21804-01	.13406+01	.16626+00	.13422-01	-.96239+00				
3	.115[illegible]2+01	.41114+00	-.12742+01	-.39632+00	-.12908+01	.96192+00				
4	-.65351+00	-.85088+00	.10476+01	.61445+00	.11994+01	-.96127+00				
5	-.18066-01	.11589+01	-.65447+00	-.81388+00	-.10718+01	.96021+00				
6	.69006+00	-.13255+01	.25747+00	.98861+00	.91187+00	-.95869+00				
7	-.11773+01	.13329+01	.21068+00	-.11333+01	-.72455+00	.95737+00				
8	.13493+01	-.11795+01	-.65352+00	.12435+01	.51551+00	-.95584+00				
9	-.11597+01	.85417+00	.10176+01	-.13160+01	-.29110+00	.95435+00				
10	.65953+00	-.45204+00	-.12589+01	.13485+01	.53032-01	-.95293+00				
11	.17588-01	.21719-01	.13484+01	-.13402+01	.17654+00	.95167+00				

12	-.69008+00	.44123+00	-.12755+01	.12911+01	-.40592+00	-.95050+00
13	.11779+01	-.89085+00	.10489+01	-.12026+01	.62266+00	.94945+00
14	-.13505+01	.11580+01	-.69564+00	.10777+01	-.82060+00	-.94872+00
15	.11618+01	-.13255+01	.25833+00	-.92001+00	.99379+00	.94819+00
16	-.66191+00	.13330+01	.21014+00	.73435+00	-.11373+01	-.94771+00
17	-.14948-01	-.11798+01	-.65368+00	-.52639+00	.12463+01	.94755+00
18	.68752+00	.88128+00	.10188+01	.30248+00	-.13170+01	-.94763+00
19	-.11769+01	-.48220+00	-.12613+01	-.69416-01	.13499+01	.94761+00
20	.13492+01	.21986-01	.13521+01	-.16571+00	-.13407+01	-.94773+00
21	-.11608+01	.44091+00	-.12803+01	.39577+00	.12915+01	.94807+00
22	.66120+00	-.86058+00	.10546+01	-.61372+00	-.12034+01	-.94863+00
23	.15866-01	.11576+01	-.70232+00	.81297+00	.10789+01	.94945+00
24	-.68876+00	-.13248+01	.26549+00	-.98754+00	-.92212+00	-.95026+00
25	.11773+01	.13322+01	.20323+00	.11321+01	.73763+00	.95109+00
26	-.13508+01	-.11789+01	-.64743+00	-.12422+01	-.53103+00	-.95204+00
27	.11624+01	.88344+00	.10138+01	.13146+01	.30861+00	.95300+00
28	-.66285+00	-.48140+00	-.12579+01	-.13470+01	-.76718-01	-.95403+00
29	-.13476-01	.21304-01	.13505+01	.13384+01	-.15768+00	.95514+00
30	.68682+00	.44134+00	-.12803+01	-.12893+01	.38748+00	-.95636+00
31	-.11755+01	-.86073+00	.10556+01	.12008+01	-.60580+00	.95768+00
32	.13486+01	.11576+01	-.70410+00	-.10759+01	.80576+00	-.95885+00
33	-.11626+01	-.13248+01	.26825+00	.91839+00	-.98115+00	.95964+00
34	.66426+00	.13322+01	.19986+00	-.73288+00	.11272+01	-.96044+00
35	.12129-01	-.11791+01	-.64412+00	.52509+00	-.12397+01	.96133+00
36	-.68526+00	.86383+00	.10108+01	-.30139+00	.13150+01	-.96221+00

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+++  @ FREE         UNIT01.

+++  @ ASG,UPR      CYL*DAAM.,          F/      4/TRK/    1024
+++  @ USE          ?.CYL*DAAM.
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MATRIX APPEARING IN DAAT EQUATIONS:

	1	2	3	4	5	6	7	8	9	10
1	.27090+00	-.10410+00	-.97821-02	-.63486-02	-.35880-02	-.23559-02	-.16731-02	-.12932-02	-.10255-02	-.84085-03
2	-.10410+00	.27090+00	-.10410+00	-.97821-02	-.63487-02	-.35890-02	-.23356-02	-.16730-02	-.12932-02	-.10251-02
3	-.97821-02	-.10410+00	.27090+00	-.10410+00	-.97822-02	-.63477-02	-.35895-02	-.23352-02	-.16732-02	-.12936-02
4	-.63486-02	-.97821-02	-.10410+00	.27090+00	-.10410+00	-.97821-02	-.63478-02	-.35892-02	-.23360-02	-.16728-02
5	-.35880-02	-.63487-02	-.97822-02	-.10410+00	.27090+00	-.10410+00	-.97822-02	-.63483-02	-.35881-02	-.23364-02
6	-.23559-02	-.35890-02	-.63477-02	-.97821-02	-.10410+00	.27090+00	-.10410+00	-.97830-02	-.63479-02	-.35885-02
7	-.16731-02	-.23356-02	-.35895-02	-.63478-02	-.97822-02	-.10410+00	.27090+00	-.10410+00	-.97829-02	-.63478-02
8	-.12932-02	-.16730-02	-.23352-02	-.35892-02	-.63483-02	-.97830-02	-.10410+00	.27090+00	-.10410+00	-.97821-02
9	-.10255-02	-.12932-02	-.16732-02	-.23360-02	-.35881-02	-.63479-02	-.97829-02	-.10410+00	.27090+00	-.10410+00
10	-.84085-03	-.10251-02	-.12936-02	-.16728-02	-.23364-02	-.35885-02	-.63478-02	-.97821-02	-.10410+00	.27090+00
11	-.72251-03	-.84765-03	-.10247-02	-.12954-02	-.16725-02	-.23362-02	-.35891-02	-.63483-02	-.97819-02	-.10410+00
12	-.63143-03	-.72190-03	-.84804-03	-.10245-02	-.12939-02	-.16729-02	-.23356-02	-.35882-02	-.63492-02	-.97820-02
13	-.56527-03	-.63116-03	-.72214-03	-.84760-03	-.10250-02	-.12931-02	-.16732-02	-.23303-02	-.35877-02	-.63480-02
14	-.51517-03	-.56521-03	-.63087-03	-.72280-03	-.84700-03	-.10257-02	-.12933-02	-.16724-02	-.23361-02	-.35885-02
15	-.47945-03	-.51541-03	-.56543-03	-.63063-03	-.72350-03	-.84635-03	-.10250-02	-.12938-02	-.16724-02	-.23361-02
16	-.45450-03	-.47992-03	-.51530-03	-.56522-03	-.63028-03	-.72340-03	-.84664-03	-.10253-02	-.12939-02	-.16727-02
17	-.43924-03	-.45472-03	-.47947-03	-.51529-03	-.56537-03	-.63042-03	-.72353-03	-.84696-03	-.10250-02	-.12935-02
18	-.42754-03	-.43963-03	-.45465-03	-.48007-03	-.51470-03	-.56573-03	-.63064-03	-.72306-03	-.84738-03	-.10248-02
19	-.42329-03	-.42766-03	-.43557-03	-.45415-03	-.48003-03	-.51474-03	-.56565-03	-.63070-03	-.72251-03	-.84748-03
20	-.42754-03	-.42305-03	-.42762-03	-.43613-03	-.45384-03	-.48047-03	-.51506-03	-.56534-03	-.63127-03	-.72232-03
21	-.43575-03	-.42769-03	-.42295-03	-.42740-03	-.43512-03	-.45398-03	-.48049-03	-.51526-03	-.56477-03	-.63100-03
22	-.45449-03	-.43598-03	-.42742-03	-.42339-03	-.42681-03	-.43643-03	-.45409-03	-.47979-03	-.51578-03	-.56527-03
23	-.47935-03	-.45457-03	-.43618-03	-.42717-03	-.42396-03	-.42677-03	-.43560-03	-.45489-03	-.47966-03	-.51502-03
24	-.51516-03	-.47990-03	-.45444-03	-.43563-03	-.42747-03	-.42371-03	-.42736-03	-.43572-03	-.45416-03	-.48016-03

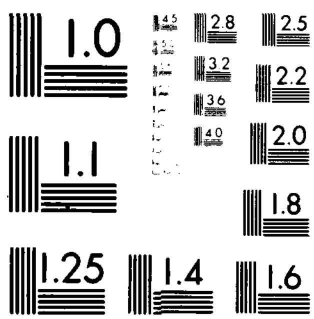
25	-.56529-03	-.51557-03	-.47910-03	-.45596-03	-.43554-03	-.42711-03	-.42396-03	-.42729-03	-.43543-03	-.45467-03
26	-.63144-03	-.56425-03	-.51635-03	-.47905-03	-.45497-03	-.43627-03	-.42661-03	-.42335-03	-.42814-03	-.43558-03
27	-.72255-03	-.63153-03	-.56450-03	-.51534-03	-.47974-03	-.45421-03	-.43680-03	-.42703-03	-.42288-03	-.42756-03
28	-.84685-03	-.72260-03	-.63109-03	-.56543-03	-.51531-03	-.48010-03	-.45364-03	-.43615-03	-.42745-03	-.42369-03
29	-.10255-02	-.84678-03	-.72350-03	-.63044-03	-.56508-03	-.51452-03	-.48090-03	-.45408-03	-.43648-03	-.42650-03
30	-.12932-02	-.10258-02	-.84580-03	-.72385-03	-.63052-03	-.56627-03	-.51379-03	-.48082-03	-.45376-03	-.43649-03
31	-.16731-02	-.12925-02	-.10266-02	-.84612-03	-.72519-03	-.63013-03	-.56623-03	-.51424-03	-.48046-03	-.45439-03
32	-.23359-02	-.16734-02	-.12925-02	-.10256-02	-.84710-03	-.72287-03	-.63100-03	-.56547-03	-.51513-03	-.47964-03
33	-.35880-02	-.23364-02	-.16729-02	-.12932-02	-.10251-02	-.84753-03	-.72221-03	-.63054-03	-.56582-03	-.51508-03
34	-.63488-02	-.35881-02	-.23362-02	-.16729-02	-.12932-02	-.10253-02	-.84739-03	-.72313-03	-.63003-03	-.56560-03
35	-.97817-02	-.63487-02	-.35885-02	-.23362-02	-.16727-02	-.12931-02	-.10254-02	-.84714-03	-.72294-03	-.63107-03
36	-.10410+00	-.97817-02	-.63488-02	-.35881-02	-.23369-02	-.16723-02	-.12931-02	-.10255-02	-.84095-03	-.72272-03
	11	12	13	14	15	16	17	18	19	20
1	-.72256-03	-.63143-03	-.56529-03	-.51517-03	-.47945-03	-.45450-03	-.43574-03	-.42754-03	-.42329-03	-.42754-03
2	-.84765-03	-.72196-03	-.63116-03	-.56521-03	-.51541-03	-.47992-03	-.45472-03	-.43563-03	-.42766-03	-.42305-03
3	-.10247-02	-.83804-03	-.72214-03	-.63087-03	-.56543-03	-.51530-03	-.47947-03	-.45465-03	-.43557-03	-.42762-03
4	-.12934-02	-.10245-02	-.84760-03	-.72280-03	-.63063-03	-.56522-03	-.51529-03	-.48007-03	-.45455-03	-.43613-03
5	-.16725-02	-.12935-02	-.10250-02	-.84706-03	-.72550-03	-.63028-03	-.56537-03	-.51470-03	-.48034-03	-.45384-03
6	-.23362-02	-.16729-02	-.12931-02	-.10257-02	-.84635-03	-.72340-03	-.63042-03	-.56578-03	-.51474-03	-.48047-03
7	-.35891-02	-.23356-02	-.16732-02	-.12933-02	-.10250-02	-.84664-03	-.72353-03	-.63064-03	-.56505-03	-.51506-03
8	-.63483-02	-.35882-02	-.23363-02	-.16724-02	-.12938-02	-.10253-02	-.84696-03	-.72306-03	-.63070-03	-.56534-03
9	-.97819-02	-.63492-02	-.35877-02	-.23361-02	-.16724-02	-.12939-02	-.10250-02	-.84738-03	-.72251-03	-.63127-03
10	-.10410+00	-.97820-02	-.63489-02	-.35886-02	-.23361-02	-.16727-02	-.12935-02	-.10248-02	-.84746-03	-.72232-03
11	.27090+00	-.10410+00	-.97821-02	-.63480-02	-.35888-02	-.23358-02	-.16731-02	-.12927-02	-.10261-02	-.84636-03
12	-.10410+00	.27090+00	-.10410+00	-.97825-02	-.63485-02	-.35887-02	-.23353-02	-.16733-02	-.12929-02	-.10261-02
13	-.97821-02	-.10410+00	.27090+00	-.10410+00	-.97819-02	-.63481-02	-.35891-02	-.23362-02	-.16726-02	-.12922-02
14	[illegible]	-.97825-02	-.10410+00	.27090+00	-.10410+00	-.97825-02	-.63484-02	-.35883-02	-.23363-02	-.16727-02
15	[illegible]	-.63485-02	-.97819-02	-.10410+00	.27090+00	-.10410+00	-.97822-02	-.63484-02	-.35882-02	-.23363-02
16	-.23358-02	-.35887-02	-.63481-02	-.97825-02	-.10410+00	.27090+00	-.10410+00	-.97827-02	-.63487-02	-.35886-02
17	[illegible]	-.23353-02	-.35891-02	-.63484-02	-.97822-02	-.10410+00	.27090+00	-.10410+00	-.97818-02	-.63483-02
18	[illegible]	-.16733-02	-.23362-02	-.35883-02	-.63487-02	-.97827-02	-.10410+00	.27090+00	-.10410+00	-.97818-02
19	[illegible]	-.12929-02	-.16726-02	-.23363-02	-.35882-02	-.63487-02	-.97818-02	-.10410+00	.27090+00	-.10410+00
20	[illegible]	-.10261-02	-.12932-02	-.16727-02	-.23363-02	-.35885-02	-.63483-02	-.97818-02	-.10410+00	.27090+00
21	[illegible]	[illegible]	-.10262-02	-.12931-02	-.16725-02	-.23361-02	-.35886-02	-.63487-02	-.97820-02	-.10410+00
22	[illegible]	[illegible]	-.84640-03	-.10260-02	-.12930-02	-.16726-02	-.23364-02	-.35883-02	-.63485-02	-.97819-02
23	-.56571-03	-.63092-03	-.72251-03	-.84662-03	-.10256-02	-.12933-02	-.16728-02	-.23363-02	-.35883-02	-.63486-02
24	-.51461-03	-.56537-03	-.63125-03	-.72284-03	-.84693-03	-.10255-02	-.12935-02	-.16724-02	-.23362-02	-.35880-02
25	-.48023-03	-.51570-03	-.56430-03	-.63155-03	-.72293-03	-.84660-03	-.10249-02	-.12940-02	-.16724-02	-.23370-02
26	-.45381-03	-.48310-03	-.51625-03	-.56466-03	-.63023-03	-.72379-03	-.84715-03	-.10244-02	-.12912-02	-.16716-02
27	-.43617-03	-.45339-03	-.47981-03	-.51484-03	[illegible]	-.63000-03	-.72295-03	-.84742-03	-.10251-02	-.12938-02
28	-.42748-03	-.43645-03	-.45460-03	-.48010-03	-.51491-03	-.56557-03	-.63060-03	-.72500-03	-.84679-03	-.10255-02
29	-.42345-03	-.42815-03	-.43547-03	-.45408-03	-.48063-03	-.51422-03	-.56578-03	-.63109-03	-.72253-03	-.84721-03
30	-.42736-03	-.42316-03	-.42731-03	-.43619-03	-.45366-03	-.48098-03	-.51497-03	-.56442-03	-.63148-03	-.72214-03
31	-.43568-03	-.42704-03	-.42402-03	-.42726-03	-.43614-03	-.45420-03	-.47967-03	-.51569-03	-.56475-03	-.63147-03
32	-.45463-03	-.43600-03	-.42704-03	-.42367-03	-.42797-03	-.43576-03	-.45478-03	-.47939-03	-.51619-03	-.56469-03
33	-.47993-03	-.45446-03	-.43562-03	-.42741-03	-.42354-03	-.42791-03	-.43531-03	-.45504-03	-.47990-03	-.51540-03
34	-.51497-03	-.48036-03	-.45415-03	-.43597-03	-.42742-03	-.42235-03	-.42786-03	-.43584-03	-.45445-03	-.47977-03
35	-.56461-03	-.51537-03	-.48038-03	-.45376-03	-.43584-03	-.42738-03	-.42322-03	-.42669-03	-.43713-03	-.45372-03
36	-.63166-03	-.56443-03	-.51523-03	-.48002-03	-.45401-03	-.43574-03	-.42720-03	-.42419-03	-.42623-03	-.43677-03
	21	22	23	24	25	26	27	28	29	30
1	-.43575-03	-.43349-03	-.47945-03	-.51516-03	-.56529-03	-.63144-03	-.72255-03	-.84685-03	-.10255-02	-.12932-02
2	-.42769-03	-.43596-03	-.45467-03	-.47990-03	-.51557-03	-.56425-03	-.63153-03	-.72260-03	-.84673-03	-.10258-02
3	-.42295-03	-.42742-03	-.43618-03	-.45444-03	-.47910-03	-.51635-03	-.56450-03	-.63109-03	-.72350-03	-.84580-03
4	-.42740-03	-.42339-03	-.42717-03	-.43583-03	-.45596-03	-.47905-03	-.51534-03	-.56543-03	-.63044-03	-.72385-03
5	-.43612-03	-.42681-03	-.42396-03	-.42747-03	-.43554-03	-.45497-03	-.47974-03	-.51531-03	-.56508-03	-.63052-03
6	-.45398-03	-.43643-03	-.42677-03	-.42371-03	-.42711-03	-.43627-03	-.45421-03	-.48010-03	-.51452-03	-.56627-03
7	-.48049-03	-.45409-03	-.43560-03	-.42736-03	-.42396-03	-.42661-03	-.43680-03	-.45364-03	-.48090-03	-.51379-03
8	-.51526-03	-.47979-03	-.45439-03	-.43572-03	-.42729-03	-.42335-03	-.42703-03	-.43615-03	-.45408-03	-.48082-03

9	[illegible]	[illegible]	-.47966-03	-.45416-03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	-.63100-03	[illegible]	-.51502-03	-.46016-03	[illegible]	-.43558-03	-.42756-03	[illegible]	-.42650-03	-.43649-03
11	[illegible]	[illegible]	-.56574-03	[illegible]	[illegible]	-.45461-03	[illegible]	[illegible]	-.42545-03	-.42736-03
12	[illegible]	[illegible]	[illegible]	-.56537-03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	-.10262-02	[illegible]	-.72251-03	[illegible]	[illegible]	-.51625-03	[illegible]	[illegible]	[illegible]	-.42731-03
14	[illegible]	[illegible]	[illegible]	-.72281-03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	-.10258-02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	-.12930-02	[illegible]	[illegible]	[illegible]	-.63600-03	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	-.16726-02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	-.23362-02	[illegible]	[illegible]	-.10251-02	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	-.35880-02	[illegible]	[illegible]	-.12938-02	[illegible]	[illegible]	-.72214-03
21	.27090+00	-.10410+00	-.97821-02	[illegible]	[illegible]	-.23366-02	-.16726-02	-.12931-02	[illegible]	-.84666-03
22	-.10410+00	.27090+00	-.10410+00	[illegible]	[illegible]	-.35891-02	-.23355-02	[illegible]	[illegible]	[illegible]
23	-.97821-02	-.10410+00	.27090+00	-.10410+00	[illegible]	[illegible]	-.35891-02	[illegible]	[illegible]	-.12926-02
24	[illegible]	[illegible]	-.10410+00	.27090+00	[illegible]	-.97518-02	[illegible]	[illegible]	[illegible]	-.16728-02
25	[illegible]	[illegible]	-.97824-02	-.10410+00	[illegible]	-.10410+00	-.97827-02	[illegible]	-.35878-02	[illegible]
26	[illegible]	[illegible]	-.63482-02	-.97818-02	[illegible]	.27090+00	-.10410+00	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	-.35891-02	-.63480-02	[illegible]	[illegible]	.27090+00	-.10410+00	[illegible]	[illegible]
28	[illegible]	[illegible]	-.23360-02	-.35884-02	[illegible]	[illegible]	-.10410+00	[illegible]	-.10410+00	[illegible]
29	[illegible]	[illegible]	-.16734-02	-.23360-02	[illegible]	[illegible]	-.97824-02	-.10410+00	[illegible]	-.10410+00
30	[illegible]	[illegible]	-.12926-02	-.16728-02	[illegible]	-.35881-02	[illegible]	-.97833-02	-.10410+00	.27090+00
31	-.72270-03	[illegible]	[illegible]	-.12932-02	-.16732-02	-.23360-02	-.35880-02	[illegible]	-.97829-02	-.10410+00
32	[illegible]	[illegible]	-.84656-03	-.10257-02	-.12930-02	-.16727-02	-.23366-02	[illegible]	[illegible]	[illegible]
33	[illegible]	[illegible]	-.72310-03	[illegible]	-.10251-02	-.12934-02	-.16726-02	-.23362-02	-.35889-02	-.63482-02
34	[illegible]	[illegible]	-.63083-03	-.72293-03	[illegible]	-.10259-02	-.12930-02	-.16730-02	-.23356-02	-.35884-02
35	[illegible]	[illegible]	-.56570-03	-.63020-03	-.72341-03	-.84706-03	-.10248-02	-.12936-02	-.16726-02	[illegible]
36	[illegible]	[illegible]	-.51486-03	-.56593-03	[illegible]	-.72216-03	-.84777-03	-.10252-02	-.12933-02	-.16727-02

	31	32	33	34	35	36
1	[illegible]	[illegible]	[illegible]	[illegible]	-.97817-02	-.10410+00
2	[illegible]	[illegible]	[illegible]	-.35881-02	[illegible]	-.97817-02
3	[illegible]	[illegible]	[illegible]	-.23362-02	[illegible]	-.63468-02
4	-.84512-03	[illegible]	-.12932-02	-.16729-02	[illegible]	-.35881-02
5	[illegible]	[illegible]	-.10251-02	-.12932-02	-.16727-02	-.23369-02
6	[illegible]	-.72287-03	[illegible]	-.10253-02	-.12931-02	-.16723-02
7	[illegible]	[illegible]	-.72221-03	[illegible]	-.10254-02	-.12931-02
8	[illegible]	[illegible]	-.63054-03	-.72313-03	[illegible]	-.10255-02
9	[illegible]	[illegible]	-.56582-03	-.63003-03	[illegible]	[illegible]
10	[illegible]	[illegible]	-.51508-03	[illegible]	[illegible]	-.72272-03
11	[illegible]	[illegible]	-.47993-03	-.51497-03	[illegible]	[illegible]
12	[illegible]	[illegible]	-.45446-03	-.48038-03	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	-.45416-03	[illegible]	-.51523-03
14	[illegible]	[illegible]	-.42741-03	-.43597-03	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	-.42742-03	[illegible]	-.45401-03
16	[illegible]	[illegible]	-.42791-03	-.42295-03	[illegible]	-.43574-03
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-.42720-03
18	[illegible]	[illegible]	-.45564-03	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	-.47890-03	-.45445-03	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	-.47977-03	[illegible]	-.43677-03
21	[illegible]	[illegible]	[illegible]	-.51574-03	[illegible]	-.45423-03
22	[illegible]	[illegible]	[illegible]	-.56478-03	[illegible]	-.47968-03
23	[illegible]	[illegible]	-.72310-03	[illegible]	[illegible]	-.51486-03
24	[illegible]	[illegible]	[illegible]	-.72293-03	[illegible]	-.56593-03
25	[illegible]	[illegible]	-.10251-02	[illegible]	-.72341-03	-.63081-03
26	[illegible]	[illegible]	-.12934-02	-.10259-02	[illegible]	-.72216-03
27	[illegible]	-.23365-02	-.16726-02	-.12930-02	-.10248-02	-.84777-03
28	[illegible]	[illegible]	-.23362-02	-.16730-02	-.12936-02	-.10252-02
29	[illegible]	[illegible]	-.35889-02	-.23356-02	-.16726-02	-.12333-02

AD-A108 773 LOCKHEED MISSILES AND SPACE CO INC PALO ALTO CA F/G 20/11
THE UNDERWATER SHOCK ANALYSIS CODE (USA-VERSION 3): A REFERENCE--ETC(U)
SEP 80 J A DERUNTZ, T L GEERS, C A FELIPPA DNA001-78-C-0029
UNCLASSIFIED LMSC-D777843 DNA-5615F NL

2 OF 3
AD A108773



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

30	-.10410+00	-.3[illegible]26-02	-.63482-02	-.35884-02	-.23[illegible]5-02	-.16727-02
31	.27090+00	-.10410+00	-.97821-02	-.63489-02	-.35883-02	-.23381-02
32	-.10410+00	.27090+00	-.10410+00	-.97822-02	-.63484-02	-.35880-02
33	-.97821-02	-.10410+00	.27090+00	-.10410+00	-.97825-02	-.63490-02
34	-.63489-02	-.9[illegible]22-02	-.10410+00	.27090+00	-.10410+00	-.97822-02
35	-.35883-02	-.63484-02	-.97825-02	-.10410+00	.27090+00	-.10410+00
36	-.23[illegible]-02	-.35880-02	-.63490-02	-.97822-02	-.10410+00	.27090+00

MATRIX APPEARING IN [illegible] EQUATIONS:

	1	2	3	4	5	6	7	8	9	10
1	.15[illegible]+01	-.8[illegible]767+00	.11455+00	-.92543-02	.48982-03	.16103-03	.10448-03	-.12290-03	.92508-0[illegible]	.36528-05
2	-.88767+00	.1[illegible]635+01	-.88766+00	.11455+00	-.92567-02	.47989-03	.16820-03	.10400-03	-.12389-0[illegible]	.[illegible]957-04
3	.11455+00	-.88766+00	.15635+01	-.88767+00	.11455+00	-.92469-02	.47537-03	.16788-03	.10564-03	-.12[illegible]-03
4	-.92[illegible]1-02	.11455+00	-.88767+00	.15635+01	-.88768+00	.11455+00	-.92494-02	.47572-03	.16835-03	.10463-03
5	.43602-03	-.9[illegible]531-02	.11455+00	-.88768+00	.15635+01	-.88768+00	.11455+00	-.92478-02	.47897-03	.16336-03
6	.16826-03	.47[illegible]9-03	-.92418-02	.11455+00	-.88768+00	.15635+01	-.88767+00	.11454+00	-.92481-02	.48301-03
7	.10[illegible]-03	.1[illegible]6-03	.46698-0[illegible]	-.92420-02	.11455+00	-.88767+00	.15635+01	-.88766+00	.11454+00	-.92488-02
8	-.12208-03	.10121-03	.17569-03	.47108-03	-.92474-02	.11454+00	-.88766+00	.15635+01	-.88767+00	.11455+00
9	.88[illegible]-05	-.12271-03	.10107-03	.16727-03	.48277-03	-.92434-02	.11454+00	-.88767+00	.15635+01	-.88767+00
10	.45[illegible]3-05	.1[illegible]71-03	-.12828-03	.10660-03	.16080-03	.47931-03	-.92430-02	.11455+00	-.88767+00	.15635+01
11	-.563[illegible]-05	-.5[illegible]71-05	.20745-03	-.12868-03	.11087-03	.16466-03	.47255-03	-.92493-02	.11455+00	-.88766+00
12	.50526-07	.10509-05	-.10046-03	.22452-04	-.13237-03	.10479-03	.17105-03	.43325-03	-.92599-02	.11455+00
13	-.53463-05	.31122-05	-.14741-05	-.43546-05	.16379-04	-.12185-03	.10136-03	.16153-03	.48964-03	-.92563-02
14	.63558-05	-.5[illegible]682-05	.76115-05	-.98888-05	.46655-05	.67125-05	-.12502-03	.11099-03	.16219-03	.47973-03
15	.27592-05	.41146-05	-.83273-05	.11868-04	-.19201-04	.12077-04	.13628-04	-.13149-03	.11176-03	.16430-03
16	-.74079-05	-.10285-05	.53428-05	-.74652-05	.15[illegible]23-04	-.19224-04	.88134-05	.13030-04	-.131[illegible]9-03	.10795-03
17	.10[illegible]-04	-.91392-05	.30097-05	.57550-05	-.10151-03	.15583-04	-.18899-04	.52978-05	.167[illegible]3-04	-.12[illegible]05-03
18	-.111[illegible]-04	.1[illegible]63-04	-.94095-05	-.35701-05	.13277-04	-.14093-04	.12512-04	-.12921-04	-.10005-0[illegible]	.1[illegible]346-04
19	.7[illegible]60-05	-.1[illegible]411-04	.15213-04	-.62498-05	-.83[illegible]74-05	.13058-04	-.65206-05	.97572-05	-.61[illegible]7-05	-.13489-05
20	-.11163-04	.93558-05	-.11930-04	.85437-05	.1[illegible]321-05	-.96583-05	.96462-05	-.72[illegible]72-05	.29010-0[illegible]	-.[illegible]98-05
21	.1[illegible]12-04	-.12445-04	.10045-04	-.64446-05	.6415[illegible]-05	.10735-05	-.87783-05	.64463-05	-.55128-0[illegible]	.[illegible]35-05
22	-.735[illegible]4-05	.11120-04	-.88419-0[illegible]	.40414-05	-.11034-05	.23939-05	-.17598-05	.22911-06	.13964-0[illegible]	-.7[illegible]113-05
23	.27374-05	-.73029-05	.82620-05	-.51878-05	-.21357-05	-.99648-06	.12896-04	-.11559-04	.11331-0[illegible]	.[illegible]530-05
24	.63[illegible]5-05	-.11652-05	-.69633-05	.12368-04	-.83[illegible]25-05	.94571-06	-.75461-05	.12721-04	-.45676-0[illegible]	-.[illegible]6256-05
25	-.52[illegible]3-05	.5[illegible]79-06	.86852-05	-.15000-04	.1[illegible]-04	-.44506-05	-.19539-05	-.7[illegible]47-05	.10208-0[illegible]	-.[illegible]291-05
26	-.45[illegible]-07	.6[illegible]75-05	-.90148-05	.96612-05	-.12[illegible]-04	.6[illegible]9-05	.16103-05	.47[illegible]82-05	-.17[illegible]9-0[illegible]	.16009-04
27	-.5[illegible]27-05	-.11187-05	.35260-05	.29974-05	.42[illegible]-06	-.20277-05	-.66061-06	-.41955-05	.10[illegible]5-0[illegible]	-.10402-04
28	.40[illegible]3-05	-.7[illegible]85-05	.62217-05	-.83178-05	.57576-05	-.61758-05	.49303-05	.64238-05	-.80212-0[illegible]	.13918-05
29	.88039-05	.7[illegible]11-05	-.19489-04	.14996-04	-.72043-05	.16082-04	-.16115-04	.14122-05	.28787-0[illegible]	.21426-05
30	-.12207-03	.3[illegible]19-05	.20[illegible]32-04	-.24512-04	.1[illegible]54-04	-.20960-04	.25843-04	-.15637-04	.42849-05	.30048-05
31	.10[illegible]35-03	-.11[illegible]80-03	-.57342-0[illegible]	.16523-04	-.16[illegible]2-04	.18893-04	-.20412-04	.19[illegible]5-04	-.971[illegible]2-05	-.[illegible]406-05
32	.16810-03	.9[illegible]85-04	-.11389-03	.69641-05	.37[illegible]5-05	-.11110-04	.82773-05	-.10[illegible]55-04	.90951-05	.38257-06
33	.48[illegible]4-03	.1[illegible]134-03	.10316-03	-.12375-03	.1[illegible]87-04	-.22557-05	-.39808-05	.12176-04	-.14106-0[illegible]	.89568-05
34	-.92[illegible]-02	.4[illegible]-03	.10823-0[illegible]	.10521-0[illegible]	-.12[illegible]-03	.13133-04	.65150-07	-.1[illegible]522-04	.18[illegible]9-0[illegible]	-.11466-04
35	.11455+00	-.9[illegible]546-02	.46150-0[illegible]	.16344-03	.10762-03	-.12393-03	.10781-04	.38370-05	-.12[illegible]7-03	.11985-05
36	-.88768+00	.11455+00	-.92548-02	.48607-03	.1[illegible]-03	.11071-03	-.12276-03	.10085-04	.49990-0[illegible]	-.85113-05

	11	12	13	14	15	16	17	18	19	20
1	-.56[illegible]-05	.5[illegible]5-06	-.58868-0[illegible]	.99353-05	-.9[illegible]29-0[illegible]	-.17025-0[illegible]	.93779-05	-.37840-05	-.26878-0[illegible]	-.3[illegible]924-05
2	-.51[illegible]7-05	-.1[illegible]3-06	.64592-0[illegible]	-.10349-04	.7[illegible]	-.10119-05	-.64403-05	.67478-05	-.24384-0[illegible]	.10370-05
3	.[illegible]-04	-.3[illegible]-05	-.28767-0[illegible]	.1[illegible]-03	-.1[illegible]-04	.63153-05	.33494-06	-.22224-05	.51424-0[illegible]	-.[illegible]370-05
4	-.12[illegible]-05	.1[illegible]-04	.20517-0[illegible]	-.11[illegible]5-0[illegible]	.1[illegible]-04	-.43[illegible]-05	.24398-05	-.1[illegible]709-05	.67487-0[illegible]	.10452-04
5	.10[illegible]2-03	-.1[illegible]-03	.1[illegible]7-0[illegible]	.4[illegible]6-05	-.[illegible]-04	.90[illegible]87-05	-.28520-05	.43816-05	.20483-0[illegible]	-.73052-05
6	.10[illegible]4-03	.13[illegible]57-03	-.122[illegible]6-0[illegible]	.76794-05	.1[illegible]-04	-.14653-04	.92188-05	-.56608-05	.30580-0[illegible]	-.12076-05
7	.47956-03	.10741-03	.10167-03	-.12556-03	.1[illegible]2-04	.79461-05	-.12669-04	.64556-05	-.83985-0[illegible]	.35846-05
8	-.92595-02	.48466-03	.16189-03	.10696-03	-.12[illegible]2-03	.51353-05	.69931-05	-.77458-05	.23673-0[illegible]	-.21307-05
9	.11455+00	-.92590-02	.48935-03	.16418-03	.10474-03	-.12127-03	.93879-05	.14565-05	-.67910-0[illegible]	.53605-05
10	-.88766+00	.11455+00	-.92563-02	.47965-03	.10[illegible]13-03	.10581-03	-.12473-03	.12578-04	.39210-0[illegible]	-.10303-04

11	.15635+01	-.88768+00	.11455+00	-.92465-02	.47519-03	.16958-03	.10450-03	-.12516-03	.11068-03	.54593-05
12	-.88768+00	.15635+01	-.88768+00	.11455+00	-.92479-02	.47535-03	.16677-03	.11042-03	-.12981-03	.12665-04
13	.11455+00	-.88768+00	.15635+01	-.88767+00	.11455+00	-.92481-02	.48081-03	.15871-03	.11104-03	-.12810-03
14	-.92456-02	.11454+00	-.88767+00	.15635+01	-.88767+00	.11455+00	-.92522-02	.48415-03	.16156-03	.10915-03
15	.47674-03	-.92501-02	.11455+00	-.88767+00	.15635+01	-.88767+00	.11454+00	-.92410-02	.48353-03	.16277-03
16	.16835-03	.47612-03	-.92459-02	.11454+00	-.88767+00	.15635+01	-.88766+00	.11454+00	-.92534-02	.48095-03
17	.10129-03	.17482-03	.47326-03	-.92489-02	.11455+00	-.88766+00	.15635+01	-.88767+00	.11455+00	-.92508-02
18	-.11813-03	.93462-04	.16475-03	.48237-03	-.92495-02	.11454+00	-.88767+00	.15635+01	-.88768+00	.11455+00
19	.33106-05	-.11857-03	.10759-03	.16194-03	.48367-03	-.92530-02	.11455+00	-.88768+00	.15635+01	-.88768+00
20	.12354-04	.79614-06	-.12205-03	.10739-03	.16220-03	.47923-03	-.92494-02	.11455+00	-.88768+00	.15635+01
21	-.19139-04	.18538-04	.83641-06	-.12146-03	.10633-03	.16464-03	.47968-03	-.92533-02	.11455+00	-.88768+00
22	.16213-04	-.19400-04	.12212-04	.34305-05	-.12150-03	.10799-03	.16167-03	.48345-03	-.92525-02	.11455+00
23	-.13274-04	.93210-05	-.87257-05	.85812-05	.75889-05	-.12490-03	.10749-03	.16156-03	.48276-03	-.92531-02
24	.13691-04	-.73344-05	.32220-05	-.98286-05	.53443-05	.10057-04	-.12818-03	.11165-03	.16139-03	.48653-03
25	-.26220-05	-.16013-06	.60301-05	-.98455-07	-.12179-04	.88255-05	.17050-04	-.13486-03	.11401-03	.15201-03
26	-.86487-05	.80970-05	-.66580-05	-.59392-07	.15405-04	-.22221-04	.21386-05	.23584-04	-.13767-03	.12124-03
27	.90973-05	-.81398-05	.26682-06	.10442-04	-.17039-04	.19803-04	-.12712-04	-.11815-05	.16490-04	-.13184-03
28	-.79667-05	.16571-04	-.86594-05	-.51267-05	.12510-04	-.13383-04	.12627-04	-.12128-04	.56148-05	.10849-04
29	.44205-05	-.17135-04	.15769-04	-.15718-05	-.12332-04	.19363-04	-.13583-04	.58250-05	-.63909-05	.78259-05
30	-.78155-05	.77804-05	-.73400-05	.62556-05	.46552-05	-.15342-04	.96750-05	.31892-05	-.32320-05	-.24355-05
31	.12633-04	-.47015-05	-.20261-05	-.49376-05	.63799-05	-.23948-05	.10303-05	-.33539-05	.61718-05	-.52679-06
32	-.84164-05	.93317-05	-.41241-05	.12215-05	-.37903-05	.12589-04	-.11527-04	.68363-05	-.68568-05	.24465-05
33	-.24922-05	-.56975-05	.12691-04	-.81832-05	.39962-05	-.14705-04	.19347-04	-.14949-04	.10789-04	-.33483-05
34	.91949-05	-.68633-05	-.23315-05	.90543-05	-.82674-05	.10816-04	-.14733-04	.12260-04	-.60741-05	.13816-06
35	.59559-06	.48554-05	-.75437-05	.29995-05	.43214-05	-.87552-05	.60673-05	.88962-06	-.44001-05	.33745-05
36	-.16617-05	.32071-05	.71590-05	-.10309-04	-.11438-05	.11567-04	-.62507-05	-.50903-05	.65620-05	.23152-07
	21	22	23	24	25	26	27	28	29	30
1	.93710-05	-.66811-05	-.99903-06	.99332-05	-.50504-05	.45665-06	-.56467-05	.40595-05	.91810-05	-.12290-03
2	-.89381-05	.10543-04	-.41306-05	-.58745-05	.30258-05	.55201-05	-.11827-05	-.72108-05	.66254-05	.64161-05
3	.73925-05	-.73037-05	.59931-05	-.14532-05	.27243-06	-.24070-05	.14810-05	.50498-05	-.14540-04	.11681-04
4	-.11758-04	.71337-05	-.68433-05	.10831-04	-.85540-05	.15607-05	.70311-05	-.10262-04	.16049-04	-.19890-04
5	.13756-04	-.79781-05	.13617-05	-.86220-05	.14534-04	-.97051-05	-.15987-05	.82719-05	-.11025-04	.14606-04
6	-.53280-05	.76475-05	-.31107-05	.13435-05	-.46328-05	.82056-05	-.50431-05	-.25018-05	.11379-04	-.14973-04
7	-.35519-05	-.26601-05	.10447-04	-.61188-05	-.16539-05	-.20299-05	.63239-05	-.92806-06	-.12310-04	.23025-04
8	.81700-05	-.75718-05	-.33842-05	.87246-05	-.74011-05	.62611-05	-.54703-05	.49308-05	.33700-05	-.16609-04
9	-.76870-05	.10142-04	-.58448-05	-.26067-05	.16032-04	-.16656-04	.68682-05	-.27775-05	.18781-05	.30914-05
10	.93470-05	-.91161-05	.10062-04	-.56366-05	-.87428-05	.16247-04	-.97869-05	.25897-05	-.27319-05	.48956-05
11	-.15025-04	.17442-04	-.14725-04	.12728-04	-.14431-05	-.64976-05	.91763-05	-.97245-05	.67443-05	-.53968-05
12	.10632-04	-.20220-04	.11524-04	-.41338-05	-.37410-05	.90655-05	-.84364-05	.16191-04	-.16538-04	.62392-05
13	.84571-05	.97936-05	-.98957-05	.24915-05	.57009-05	-.38343-05	-.14156-05	-.87622-05	.16046-04	-.73938-05
14	-.12474-03	.69669-05	.62412-05	-.97570-05	.24515-05	-.40867-05	.12653-04	-.55647-05	-.26593-05	.86954-05
15	.10773-03	-.12250-03	.75659-05	.62737-05	-.98133-05	.11483-04	-.14670-04	.10061-04	-.58219-05	-.33688-05
16	.16271-03	.10789-03	-.12260-03	.68953-05	.93516-05	-.20294-04	.17459-04	-.91073-05	.10347-04	-.76146-05
17	.47983-03	.16271-03	.10768-03	-.12469-03	.83958-05	.10621-04	-.16051-04	.98738-05	-.73731-05	.81118-05
18	-.92593-02	.48119-03	.16266-03	.10910-03	-.12795-03	.12510-04	.54387-05	-.10350-04	.53570-05	-.20920-05
19	.11455+00	-.92537-02	.48359-03	.16160-03	.11109-03	-.12980-03	.11067-04	.40079-05	-.68328-05	.23191-05
20	-.88767+00	.11455+00	-.92520-02	.48407-03	.15880-03	.11027-03	-.12523-03	.12605-04	.13355-05	-.76614-05
21	.15635+01	-.88768+00	.11455+00	-.92523-02	.48116-03	.16649-03	.10470-03	-.12469-03	.93575-05	.70096-05
22	-.88768+00	.15635+01	-.88767+00	.11454+00	-.92456-02	.47532-03	.16972-03	.10585-03	-.12116-03	.51535-05
23	.11455+00	-.88767+00	.15635+01	-.88766+00	.11455+00	-.92503-02	.47494-03	.16523-03	.10441-03	-.12333-03
24	-.92557-02	.11454+00	-.88766+00	.15635+01	-.88768+00	.11455+00	-.92436-02	.47973-03	.16417-03	.10704-03
25	.48973-03	-.92468-02	.11455+00	-.88768+00	.15635+01	-.88767+00	.11454+00	-.92533-02	.48905-03	.16207-03
26	.15812-03	.47339-03	-.92463-02	.11455+00	-.88767+00	.15635+01	-.88766+00	.11455+00	-.92612-02	.48431-03
27	.10803-03	.17204-03	.47252-03	-.92457-02	.11454+00	-.88766+00	.15635+01	-.88767+00	.11455+00	-.92475-02
28	-.12193-03	.10165-03	.16776-03	.48008-03	-.92531-02	.11455+00	-.88767+00	.15635+01	-.88765+00	.11453+00
29	.36560-05	-.11173-03	.97915-04	.16532-03	.48876-03	-.92617-02	.11454+00	-.88765+00	.15634+01	-.88765+00
30	.86083-05	-.25854-05	-.11526-03	.10461-03	.16215-03	.48581-03	-.92499-02	.11453+00	-.88765+00	.15635+01
31	-.90379-05	.82500-05	.70473-05	-.12244-03	.10144-03	.16462-03	.48585-03	-.92490-02	.11454+00	-.86766+00

32	.29591-05	-.96151-05	.92448-05	.70895-05	-.12159-03	.10752-03	.15846-03	.46533-03	-.92497-02	.11454+00
33	.28377-05	.23864-05	-.13199-04	.49141-05	.13368-04	-.12570-03	.10794-03	.16422-03	.47554-03	-.92470-02
34	-.55063-06	-.71973-06	.88774-05	-.13164-04	.82859-05	.58177-05	-.12229-03	.10344-03	.17038-03	.48103-03
35	-.92623-06	.50054-05	-.12339-04	.17500-04	-.17594-04	.34090-05	.17730-04	-.12829-03	.10779-03	.16001-03
36	-.37281-05	-.54487-06	.10553-04	-.14716-04	.97666-05	-.24974-05	-.55043-05	.14390-04	-.12560-03	.10784-03

	31	32	33	34	35	36
1	.10448-03	.10087-03	.48983-03	-.92568-02	.11455+00	-.88768+00
2	-.11846-03	.10491-03	.15774-03	.48659-03	-.92548-02	.11455+00
3	.26789-05	-.11900-03	.10609-03	.16301-03	.48133-03	-.92545-02
4	.91395-05	.11102-04	-.12389-03	.10517-03	.16320-03	.48648-03
5	-.11746-04	.10600-04	.14447-03	-.12397-03	.10596-03	.15760-03
6	.13714-04	-.10416-04	.27984-04	.10201-04	-.11434-03	.10597-03
7	-.21047-04	.13886-04	-.11761-04	.91068-05	.26341-05	-.11849-03
8	.23018-04	-.13018-04	.14605-04	-.19898-04	.11677-04	.63560-05
9	-.12251-04	.11394-04	-.10997-04	.16054-04	-.14920-04	.67054-05
10	-.91011-06	-.23125-05	.82922-05	-.10300-04	.50349-05	-.79281-05
11	.62698-05	-.50766-05	-.16243-05	.70002-05	.14773-05	-.12219-05
12	-.19554-05	.81482-05	-.96993-05	.15666-05	-.23754-05	.55714-05
13	-.16937-05	-.44144-05	.14497-04	-.85513-05	.22609-06	.36022-05
14	-.60815-05	.12456-05	-.86130-05	.10792-04	-.14730-05	-.59337-05
15	.10456-04	-.30306-05	.14269-05	-.10655-05	.60373-05	-.40396-05
16	-.26451-05	.76853-05	-.79912-05	.71808-05	-.78970-05	.10576-04
17	-.35237-05	-.54022-05	.13735-04	-.11755-04	.73947-05	-.88799-05
18	.35432-05	-.12594-05	-.72617-05	.10413-04	-.47828-05	.15437-05
19	-.75283-06	.30903-05	.20186-05	-.67192-05	.52286-05	-.23441-05
20	.63878-05	-.59987-05	.43804-05	-.16951-05	-.23236-05	.66698-05
21	-.13956-04	.91119-05	-.28013-05	.24337-05	.30580-06	-.63592-05
22	.79312-05	-.14165-04	.90747-05	-.43502-05	.63653-05	-.15757-05
23	.11166-04	.91055-05	-.15743-04	.10217-04	-.10596-04	.76305-05
24	-.12374-03	.71134-05	.44899-05	-.11420-04	.13023-04	-.10341-04
25	.10136-03	-.12206-03	.15169-04	.20740-05	-.98451-05	.64285-05
26	.16737-03	.10635-03	-.12969-03	.14275-04	-.34639-05	-.99975-07
27	.47954-03	.16182-03	.10884-03	-.12451-03	.18633-04	-.50775-05
28	-.92454-02	.48256-03	.16349-03	.10464-03	-.12882-03	.14959-04
29	.11453+00	-.92474-02	.47870-03	.16821-03	.10555-03	-.12387-03
30	-.88765+00	.11454+00	-.92446-02	.47564-03	.10783-03	.10411-03
31	.15635+01	-.88765+00	.11454+00	-.92460-02	.47502-03	.16837-03
32	-.88766+00	.15635+01	-.88766+00	.11454+00	-.92461-02	.47994-03
33	.11455+00	-.88766+00	.15635+01	-.88767+00	.11454+00	-.92541-02
34	-.92551-02	.11455+00	-.88767+00	.15635+01	-.88766+00	.11455+00
35	.48319-03	-.92511-02	.11454+00	-.88766+00	.15635+01	-.88768+00
36	.16410-03	.48561-03	-.92566-02	.11455+00	-.88768+00	.15635+01

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++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+            A U X I L I A R Y   S T O R A G E   T A B L E           +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                                    +
+LDI EDN(Q+EFN) IFN   EC UP SEC CDLOC   NEXT  LIMIT    READ WRITTEN +
+  3 CYL*DAAM    3     36 UPR28    94     94  65536       0    2592 +
+                                                                    +
+                     1 ACTIVE DEVICES ( 0 FULL)                     +
+       0 TP-OPS.      16 WRITES,       1 READS,     5950 WORDS XFD  +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

+++  @ FREE        CYL*DAAM.
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APPENDIX B

USER INFORMATION FOR THE AUGMENTED MATRIX PREPROCESSOR AUGMAT

This appendix includes a copy of the users manual, and a sample input deck and subsequent output for the infinite cylindrical shell problem presented in Section 4.

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                              A U G M A T

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      THIS FUNCTIONAL COMPONENT OF THE UNDERWATER SHOCK ANALYSIS CODE
      ACCEPTS DATA FROM THE FLUID MASS MATRIX PROCESSOR AND THE
      STRUCTURAL ANALYZER TO CONSTRUCT THE SPECIFIC CONSTANTS AND ARRAYS
      THAT ARE USED IN THE STAGGERED SOLUTION PROCEDURE FOR THE
      TRANSIENT RESPONSE ANALYSIS OF SUBMERGED STRUCTURES

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      THIS PROGRAM WAS DEVELOPED AND CODED BY JOHN A. DERUNTZ. JR.
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      CALIFORNIA. PLEASE CONSULT WITH AUTHOR BEFORE MAKING CHANGES
      AND ALSO REPORT ANY MALFUNCTIONS OR PROBLEMS. WRITE IN CARE OF
      LOCKHEED PALO ALTO RESEARCH LABORATORY. BLDG 205. DEPT 52-33.
      3251 HANOVER ST.. PALO ALTO. CALIF.. 94304 OR CALL 415-493-4411
      EXTS. 45069 OR 45133.                          SEPTEMBER. 1980

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 W A R N I N G    F R O M    T H E    P R O G R A M M E R    G E N E R A L

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      THIS CODE CONTAINS THE SPECIAL INGREDIENT DMGASP NOT FOUND IN
      OTHER BRANDS. DMGASP IS A DATA MANAGEMENT UTILITY MODULE THAT
      WILL ACTIVATE AND DEACTIVATE ALL AUXILIARY STORAGE DATA FILES
      REFERENCED BY THE CODE. HENCE THE NAMES OF SUCH FILES SHOULD NOT
      APPEAR ON ANY CONTROL CARDS IN THE RUN STREAM WHICH MIGHT NORMALLY
      ACTIVATE AND DEACTIVATE THE FILES. THE USER IS ALSO CAUTIONED THAT
      PREVIOUSLY CREATED FILES MUST ALREADY BE RESIDENT IN THE SYSTEM
      BEFORE THE RUN IS INITIATED. IF A FILE HAS BEEN ROLLED-OUT TO TAPE
      DMGASP WILL ATTEMPT TO HAVE THE FILE ROLLED-IN EVERY 15 SECONDS
      FOR UP TO 6 MINUTES ON THE UNIVAC 1100-EXEC 8 OPERATING SYSTEM.
      IF AN EXISTING DATA FILE HAS NOT BEEN REFERENCED FOR SOME TIME IT
      IS THEREFORE GOOD POLICY TO SIMPLY ACTIVATE AND DEACTIVATE THE
      FILE BEFORE EXECUTION OF THIS CODE. IF THE USER ATTEMPTS TO CREATE
      A NEW DATA FILE WITH A NAME WHICH IS ALREADY ASSIGNED TO AN
      EXISTING FILE. THE UNIVAC VERSION OF DMGASP WILL MODIFY THE NAME
      OF THE FILE GENERATED BY THIS RUN TO AVOID ANY CONFLICT. FILE NAME
      DUPLICATION WILL CAUSE NO PROBLEM ON THE CDC SCOPE OPERATING
      SYSTEM AS SCOPE WILL SIMPLY CATALOG A NEW CYCLE OF THE SAME FILE.
      ON THE OTHER HAND THE CDC NOS SYSTEM IS SIMILAR TO UNIVAC IN THIS
      REGARD AND THE RUN WILL ABORT SINCE THE NAME-CHANGING FEATURE OF
      DMGASP HAS NOT BEEN IMPLEMENTED FOR NOS. QUALIFIER*FILENAME IS THE
      REQUIRED INPUT DATA FORMAT FOR ALL UNIVAC PERMANENT FILE NAMES.
      ON CDC SCOPE. THE QUALIFIER IS INTERPRETED AS THE USERS ID. WHICH
      IN MOST INSTALLATIONS CAN BE SELECTED ALMOST ARBITRARILY. ON CDC
      NOS. THE QUALIFIER IS INTERPRETED AS THE USERS CATALOG NUMBER.
      WHICH IS USUALLY PRESCRIBED BY THE INSTALLATION. A CYCLE NUMBER
      CAN ALSO BE APPENDED TO GIVE THE FORM QUALIFIER*FILENAME(CYCLE)
      ON CDC SCOPE

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                          P R O G R A M     S I Z E

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      ALL ARRAYS REFERRENCED IN THIS CODE THAT ARE PROBLEM DEPENDENT
      RESIDE IN BLANK COMMON. THE SIZE OF BLANK COMMON IS DETERMINED BY
      A PARAMETER STATEMENT IN THE MAIN PROGRAM FOR THE UNIVAC 1100-OS
      VERSION. HENCE A RECOMPILATION IS NECESSARY TO INCREASE OR
      DECREASE CORE ALLOCATION. IN THE CDC 6600 VERSION RECOMPILATION IS
      UNNECESSARY AS THE LENGTH OF BLANK COMMON IS SET BY A FIELD LENGTH
      REQUEST IN THE CONTROL CARD DECK

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      D E F I N I T I O N    O F    I N P U T    P A R A M E T E R S

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      INPUT VARIABLE NAMES GIVEN BELOW ARE GENERALLY THOSE WHICH ARE
      ALSO USED IN THE CODING AND THE VARIABLE TYPES CORRESPOND TO
      STANDARD FORTRAN USAGE:

                    A   -   ALPHANUMERIC
                    E   -   FLOATING POINT
                    F   -   FIXED POINT
                    I   -   INTEGER
                    L   -   LOGICAL

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      VARIABLE      TYPE                  DESCRIPTION
      --------      ----                  -----------

      STRNAM         A          NAME OF PERMANENT MASS STORAGE FILE WHICH
                                CONTAINS THE STRUCTURAL MASS AND STIFFNESS
                                MATRICES AS WELL AS BOOKEEPING INFORMATION
                                RELATING THE INTERNAL AND EXTERNAL DEGREES
                                OF FREEDOM. WHEN INTERFACING WITH THE
                                NONLINEAR STRUCTURAL ANALYZER STAGS THE
                                STIFFNESS MATRIX IS NOT PRESENT

      FLUNAM         A          NAME OF PERMANENT MASS STORAGE FILE WHICH
                                CONTAINS THE MANIPULATED DAA FORM OF THE
                                FLUID MASS MATRIX

      GEONAM         A          NAME OF PERMANENT MASS STORAGE FILE WHICH
                                CONTAINS THE FLUID MESH GEOMETRY AND
                                FLUID-STRUCTURE TRANSFORMATION DATA

      PRENAM         A          NAME OF PERMANENT MASS STORAGE FILE
                                CREATED BY THIS PROCESSOR WHICH CONTAINS
                                ALL THE INFORMATION REQUIRED TO CONDUCT
                                THE UNDERWATER SHOCK ANALYSIS OF THE
                                STRUCTURE IN QUESTION EXCEPT FOR THE
                                EXCITATION AND INTEGRATION DATA

      FRWTST         L          TRUE IF THE PERMANENT FILE CONTAINING THE
                                STRUCTURAL MASS AND STIFFNESS MATRICES
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		WAS CREATED BY BUFFERED FORTRAN WRITE STATEMENTS. OTHERWISE FALSE
SYMCON	L	TRUE IF TRANSLATIONAL CONSTRAINTS MUST BE APPLIED TO STRUCTURAL NODES DUE TO SYMMETRY CONDITIONS IF HALF OR QUARTER MODELS ARE BEING USED. OTHERWISE FALSE. CONSTRAINTS ON ROTATIONAL STRUCTURAL FREEDOMS DO NOT ENTER THE AUGMENTED MATRICES. CONSTRAINTS MUST BE APPLIED ONLY IF NDICOS = 0 (SEE BELOW)
PRTAUG	L	TRUE IF AUGMENTED FORM OF MATRICES APPEARING IN THE FLUID EQUATIONS ARE TO BE PRINTED IN FULL. OTHERWISE FALSE IN WHICH CASE ONLY THE MATRIX MASTER RECORD AND THE DIAGONAL TERMS ARE PRINTED. THE FIRST MATRIX SHOWN IS THE INVERSE FORM OF THE STRUCTURAL MASS AND IT IS THE ONLY SPARSE MATRIX IN THE FLUID EQUATIONS. HENCE A MAP OF ITS CONNECTIVITY IS ALWAYS SHOWN. THE NEXT MATRIX IS A COMBINATION OF BOTH THE FLUID AND STRUCTURE INVERSE MASS MATRICES. FOR DAA2 RUNS TWO ADDITIONAL MATRICES APPEAR THAT INVOLVE ONLY THE FLUID MASS INVERSE. THE FIRST COMES DIRECTLY FROM THE DAA1 EQUATION WHILE THE SECOND IS ITS ITERATED FORM THAT APPEARS IN THE DAA2 EQUATION. IT IS RECOMMENDED THAT A VALUE OF FALSE BE USED UNDER NORMAL CONDITIONS
PRTGMT	L	TRUE IF FLUID MESH GEOMETRY DATA IS TO BE LISTED. OTHERWISE FALSE
PRTTRN	L	TRUE IF FLUID-STRUCTURE TRANSFORMATION DATA IS TO BE LISTED. OTHERWISE FALSE
PRTSTF	L	TRUE IF SKYLINED STRUCTURAL STIFFNESS MATRIX IS TO BE DISPLAYED. OTHERWISE FALSE. WHEN INTERFACING WITH STAGS THIS VARIABLE MUST ALWAYS BE TAKEN AS FALSE SINCE THE GLOBAL STIFFNESS OPERATOR DOES NOT EXIST IN THE SAME FORM AS THAT FOR USA IN THE STAND ALONE CONFIGURATION
DAA2	E.F	A PARAMETER BOUNDED BY ZERO AND UNITY THAT GOVERNS THE USE OF THE IMPROVED DOUBLY ASYMPTOTIC APPROXIMATION. A VALUE OF ZERO REDUCES THE FLUID SOLUTION TO THE STANDARD DOUBLY ASYMPTOTIC APPROXIMATION. HOWEVER A PRECISE CHOICE FOR THIS PARAMETER IS NOT GIVEN BY ANY FUNDAMENTAL PRINCIPLE. IT HAS BEEN OBSERVED THAT A VALUE OF 1.0 LEADS TO THE BEST ACCURACY FOR A SPHERICAL SHELL WHILE A VALUE OF 0.5 SEEMS TO BE BEST FOR THE INFINITE CYLINDRICAL SHELL. IT CAN BE SHOWN THAT THIS SCALAR PARAMETER DOES HAVE A RELATIONSHIP WITH THE DIAGONAL LOCAL

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                                  CURVATURE MATRIX FOR THE FLUID ELEMENTS.
                                  IF A VALUE OF ZERO WAS USED IN THE FLUID
                                  MASS RUN AND A DAA2 RUN IS DESIRED THEN
                                  THE FLUID MASS PROCESSOR MUST BE RERUN
                                  WITH A NONZERO VALUE BEFORE FURTHER
                                  COMPUTATION CAN TAKE PLACE

          NSTR          I         NUMBER OF NODE POINTS IN STRUCTURAL MODEL

          NSFR          I         NUMBER OF STRUCTURAL DEGREES OF FREEDOM.
                                  WHEN INTERFACING WITH STAGS THIS WILL BE
                                  SIX (6) TIMES THE VALUE OF NSTR

          NFRE          I         THE LARGEST DEGREE OF FREEDOM INDEX AT ANY
                                  STRUCTURAL NODE WHICH IS REFERENCED IN THE
                                  ANALYSIS. FREEDOMS 1, 2. AND 3 ARE ASSUMED
                                  TO BE TRANSLATIONAL WHILE 4. 5. AND 6 ARE
                                  RESERVED FOR ROTATIONS. ALWAYS USE SIX (6)
                                  WHEN INTERFACING WITH STAGS

          NFTR          I         THE LARGEST TRANSLATIONAL DEGREE OF
                                  FREEDOM INDEX AT ANY NODE WHICH IS
                                  REFERENCED IN THE ANALYSIS. ALWAYS USE
                                  THREE (3) WHEN INTERFACING WITH STAGS

          MXWD          I         NUMBER OF WORDS PER BLOCK TO BE USED FOR
                                  PARTITIONED SKYLINED FLUID MATRICES.
                                  GENERALLY USE SOME MULTIPLE OF 448 TO
                                  ACCOMODATE EITHER THE 28 WORD SECTOR ON
                                  UNIVAC OR THE 64 WORD PRU ON CDC SO THAT
                                  FILE SIZE IS MINIMIZED

          NUMBLK        I         NUMBER OF BLOCKS OR MATRIX VALUE RECORDS
                                  INTO WHICH THE SKYLINED STRUCTURAL
                                  STIFFNESS MATRIX HAS BEEN PARTITIONED

          NWDBLK        I         MAXIMUM BLOCK SIZE FOR SKYLINED STRUCTURAL
                                  STIFFNESS MATRIX

          NSETLC        I         NUMBER OF DATA SETS NEEDED TO DEFINE THE
                                  TYPE OF STRUCTURAL COORDINATE SYSTEM WITH
                                  WHICH ANY PARTICULAR GENERAL FLUID ELEMENT
                                  MUST INTERFACE. THIS DATA IS NOT REQUIRED
                                  FOR SURFACE OF REVOLUTION FLUID ELEMENTS
                                  BUT INCLUDES ANY FLUID ELEMENTS THAT WERE
                                  GENERATED AUTOMATICALLY IN FLUMAS FOR A
                                  CYLINDRICAL SURFACE

          NDICOS        I         DESIGNATES THE TYPE OF COORDINATE SYSTEM
                                  USED IN THE STRUCTURAL SOLUTION.
                                  ACCEPTABLE VALUES ARE:

                                    0 - GLOBAL COORDINATES
                                    1 - LOCAL COORDINATES WITH THE FIRST
                                        DEGREE OF FREEDOM NORMAL TO THE
                                        FLUID-STRUCTURE CONTACT BOUNDARY
                                    2 - LOCAL COORDINATES WITH THE SECOND
                                        DEGREE OF FREEDOM NORMAL TO THE
```

FLUID-STRUCTURE CONTACT BOUNDARY
3 - LOCAL COORDINATES WITH THE THIRD DEGREE OF FREEDOM NORMAL TO THE FLUID-STRUCTURE CONTACT BOUNDARY

AT THIS TIME OPTIONS 1, 2, OR 3 MAY BE USED ONLY FOR RIGHT CIRCULAR CYLINDERS OR SPHERES. MORE LATITUDE IN THESE CHOICES IS ULTIMATELY PLANNED. FOR USAGE WITH STAGS A VALUE OF 0 MUST ALWAYS BE USED AS STAGS CARRIES OUT ITS OWN GLOBAL TO LOCAL TRANSFORMATION. GLOBAL COORDINATES ARE AUTOMATICALLY SET IN THIS PROCESSOR FOR ALL SURFACE OF REVOLUTION FLUID ELEMENTS

JSTART	I	FIRST OF ONE OR MORE FLUID ELEMENTS HAVING THE SAME VALUE OF NDICOS
JSTOP	I	LAST OF ONE OR MORE FLUID ELEMENTS HAVING THE SAME VALUE OF NDICOS
JINC	I	INCREMENT TO BE APPLIED IN ASSIGNING THE VALUE OF NDICOS TO FLUID ELEMENTS IN THE RANGE FROM JSTART TO JSTOP
NUMCON	I	NUMBER OF DATA SETS REQUIRED TO DEFINE THE CONSTRAINTS TO BE APPLIED TO TRANSLATIONAL STRUCTURAL DEGREES OF FREEDOM DUE TO SYMMETRY CONDITIONS. THESE CONSTRAINTS NEED BE APPLIED ONLY TO STRUCTURAL NODES ON THE WET SURFACE
ICON	I	WILL HAVE THE VALUE 1, 2, OR 3 DEPENDING UPON WHETHER THE TRANSLATIONAL CONSTRAINT IS TO BE APPLIED IN THE X, Y, OR Z GLOBAL COORDINATE DIRECTION. ONLY ONE CONSTRAINT IS ALLOWABLE AT A STRUCTURAL NODE AT THIS TIME HOWEVER THIS LIMITATION IS NOT PARTICULARLY RESTRICTIVE. CONSTRAINTS TO THE AUGMENTED MATRICES ARE REQUIRED ONLY IF A FLUID ELEMENT ASSOCIATED WITH A PARTICULAR STRUCTURAL NODE IS ORIENTED SUCH THAT THE UNIT OUTWARD NORMAL VECTOR OF THE FLUID ELEMENT HAS A COMPONENT PERPENDICULAR TO THE SYMMETRY PLANE. FOR EXAMPLE, A QUARTER CYLINDER MODEL WOULD REQUIRE A CIRCUMFERENTIAL CONSTRAINT BUT NOT AN AXIAL ONE
NSTART	I	FIRST OF ONE OR MORE STRUCTURAL NODES HAVING THE SAME VALUE OF ICON
NSTOP	I	LAST OF ONE OR MORE STRUCTURAL NODES HAVING THE SAME VALUE OF ICON
NINC	I	INCREMENT TO BE APPLIED IN ASSIGNING THE VALUE OF ICON TO STRUCTURAL NODES IN THE RANGE FROM NSTART TO NSTOP

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PRTPNT        I          A VALUE OF ONE (1) WILL PRODUCE A DISPLAY
                         OF THE DIAGONAL LOCATION POINTERS OF THE
                         SKYLINED STRUCTURAL STIFFNESS MATRIX.
                         OTHERWISE SET TO ZERO UNDER NORMAL
                         CONDITIONS

PRTVAL        I          A VALUE OF ONE (1) WILL PRODUCE A DISPLAY
                         OF THE SKYLINED STIFFNESS MATRIX.
                         OTHERWISE SET TO ZERO AND ONLY THE
                         DIAGONAL TERMS WILL BE PRINTED BY DEFAULT.
                         USE A NON-ZERO VALUE ONLY FOR DIAGNOSTIC
                         REASONS OR FOR VERY SMALL PROBLEMS AS THE
                         AMOUNT OF OUTPUT CAN BE ENORMOUS

MAPVAL        I          A VALUE OF ONE (1) WILL PRODUCE A MAP-TYPE
                         DISPLAY OF MATRIX VALUES TO SHOW THE
                         CONNECTIVITY ALONE, OTHERWISE SET TO ZERO
                         UNDER NORMAL CONDITIONS

MVR1          I          INDEX OF FIRST MATRIX VALUE RECORD TO BE
                         DISPLAYED. UNDER NORMAL CONDITIONS USE A
                         VALUE OF ZERO AND THE CODE WILL START THE
                         DISPLAY AT THE BEGINNING OF THE MATRIX.
                         USE A NON-ZERO VALUE ONLY WHEN A SPECIFIC
                         SET OF BLOCKS IS TO BE PRINTED FOR SOME
                         DIAGNOSTIC REASON

MVR2          I          INDEX OF LAST MATRIX VALUE RECORD TO BE
                         DISPLAYED. UNDER NORMAL CONDITIONS USE A
                         VALUE OF ZERO AND THE CODE WILL DISPLAY TO
                         THE END OF THE MATRIX. USE A NON-ZERO
                         VALUE ONLY WHEN A SPECIFIC SET OF BLOCKS
                         IS TO BE PRINTED FOR SOME DIAGNOSTIC
                         REASON

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            I N P U T    D A T A    C A R D    D E C K

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ALL INPUT DATA EXCEPT ALPHANUMERIC DATA MUST BE RIGHT JUSTIFIED
IN EIGHT (8) COLUMN FIELDS WHICH CAN OCCUPY THE ENTIRE CARD.
ALPHANUMERIC DATA MUST BE LEFT JUSTIFIED IN TWENTY (20) COLUMN
FIELDS. FILE NAME PLUS QUALIFIER IS CURRENTLY RESTRICTED TO
EIGHTEEN (18) CHARACTERS FOR UNIVAC OPERATION WHILE NINETEEN (19)
CHARACTERS MAY BE USED FOR CDC OPERATION

GENERAL PROBLEM DEFINITION (MAIN PROGRAM PREPROC):
--------------------------------------------------

72 COLUMN ALPHANUMERIC TITLE
STRNAM              FLUNAM              GEONAM              PRENAM
FRWTST  SYMCON  PRTAUG
PRTGMT  PRTTRN  PRTSTF
DAA2
NSTR    NSFR    NFRE    NFTR
```

```
MXWD

IF PRTSTF = .TRUE. INCLUDE THE FOLLOWING CARD

NUMBLK  NWDBLK

IF THE FLUID MODEL CONSISTS OF ONLY SURFACE OF REVOLUTION ELEMENTS
SKIP THE FOLLOWING SET OF CARDS

NSETLC
NDICOS  JSTART  JSTOP   JINC      )
   .       .       .       .      )   TOTAL = NSETLC
   .       .       .       .      )

SET SYMMETRY CONSTRAINTS (SUBROUTINE CONSTR):
---------------------------------------------

IF SYMCON = .TRUE. INCLUDE THE FOLLOWING CARDS

NUMCON
ICON    NSTART  NSTOP   NINC      )
   .       .       .       .      )   TOTAL = NUMCON
   .       .       .       .      )

DISPLAY SKYLINED STRUCTURAL STIFFNESS MATRIX (SUBROUTINE STFMAT):
-----------------------------------------------------------------

IF PRTSTF = .TRUE. INCLUDE THE FOLLOWING CARDS

PRTPNT  PRTVAL  MAPVAL
MVR1    MVR2
```

The following discussion is provided as an aid to user understanding of the sample output that is included here.

After a summary of the fluid mesh geometry arrays (see Appendix A) the first item needing explanation is that entitled "Fluid Element Wetted Freedom Indicator". This is simply a listing of the input variable NDICOS (see user manual) for each fluid element.

The section "Structural Grid Point Numbers Associated With Internal Sequence Numbers" contains a correspondence table that relates the internal sequence numbers assigned by the fluid mass processor with the external structural node number assigned by the user.

The next item entitled "Grid Point and Freedom Number for Each Row of Stiffness Matrix" identifies an integer vector that is constructed by the user in the Skyline Utility (see Figure 3-1, also Appendix E). For each structural equation the entry in the vector consists of ten times the structural node number plus the local degree of freedom number.

The last item requiring explanation is the "Freedom/Equation Correspondence Table". This is an integer matrix of 6 rows and as many columns as there are structural node points. Any particular row corresponds to a local degree of freedom number while a column corresponds to the internal sequence number for a particular external node number. The matrix entry for any particular set of row and column is the structural equation number for that pair.

Depending upon user input the structural stiffness matrix (identifier "STIF") may then be displayed as well as the appropriate fluid matrices. The matrix called TMIT corresponds to $\underset{\sim}{D}_s$ [see Eq. (2.6)], while DFDS denotes the sum of $\underset{\sim}{D}_s$ and $\underset{\sim}{D}_{f1}$ [see Eq. (2.6)]. In DAA_2 runs $\underset{\sim}{D}_{f1}$ is labeled DAA1 while $\underset{\sim}{D}_{f2}$ is labeled DAA2.

```
AUGMAT RUN FOR INFINITE CYLINDER SIMULATION
CYL*KSKY                CYL*DAAM                CYL*GEOM                CYL*PREP
         F         F         F
         T         T         T
        0.
        72       432         6         3
       448
         6      2688
         1
         1         1        00         1
         0         0         0
         0         0
```

@XQT

```
@ADD,P CYLAUGDAT

    AUGMAT RUN FOR INFINITE CYLINDER SIMULATION


 +++  @ ASG,AX       CYL*GEOM.
 +++  @ USE      14,CYL*GEOM.

    USER OPTIONS FOR THIS RUN:

    FRWTST       SYMCON       PRTAUG
      F            F            F

    PRTGMT       PRTTRN       PRTSTF
      T            T            T

    THIS IS A DAA1 RUN


    FLUID MASS DENSITY =      .10000000+01

    FLUID SOUND SPEED  =      .10000000+01


      2735 WORDS OF STORAGE REQUIRED FOR THIS RUN


 +++  @ ASG,UPR      CYL*PREP.,          F/      4/TRK/    1024
 +++  @ USE      16,CYL*PREP.

 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 +           A U X I L I A R Y    S T O R A G E    T A B L E           +
 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 +                                                                     +
 +LDI EDN(Q*EFN) IFN     EC OP SEC CDLOC    NEXT  LIMIT     READ WRITTEN +
 + 12 CYL*GEOM    14     36 AX 28     36      64  65536      766       0 +
 + 14 CYL*PREP    16     36 UPR28      9       0  65536        0       0 +
 +                                                                     +
 +                   2 ACTIVE DEVICES ( 0 FULL)                        +
 +      0 TP-OPS,       0 WRITES,      13 READS,       766 WORDS XFD   +
 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


 +++  @ FREE       CYL*GEOM.

    FLUID MESH GEOMETRIC ARRAYS:

       N     NTRA          X              Y              Z              NX             NY             NZ             A00

       1       2    .10000000+01   .00000000      .00000000      .10000000+01   .00000000      .00000000      .30504511-01
       2       2    .98480775+00   .17364818+00   .00000000      .98480775+00   .17364818+00   .00000000      .30504511-01
       3       2    .93969262+00   .34202015+00   .00000000      .93969262+00   .34202015+00   .00000000      .30504511-01
```

4	2	.86602540+00	.50000001+00	.00000000	.86602540+00	.50000001+00	.00000000	.30504511-01
5	2	.76604443+00	.64278762+00	.00000000	.76604443+00	.64278762+00	.00000000	.30504511-01
6	2	.64278760+00	.76604445+00	.00000000	.64278760+00	.76604445+00	.00000000	.30504511-01
7	2	.49999399+00	.86602541+00	.00000000	.49999399+00	.86602541+00	.00000000	.30504511-01
8	2	.34202012+00	.93969263+00	.00000000	.34202012+00	.93969263+00	.00000000	.30504511-01
9	2	.17364815+00	.98480776+00	.00000000	.17364815+00	.98480776+00	.00000000	.30504511-01
10	2	-.28810229-07	.10000000+01	.00000000	-.28810229-07	.10000000+01	.00000000	.30504511-01
11	2	-.17364822+00	.98480774+00	.00000000	-.17364822+00	.98480774+00	.00000000	.30504511-01
12	2	-.34202018+00	.93969261+00	.00000000	-.34202018+00	.93969261+00	.00000000	.30504511-01
13	2	-.50000002+00	.86602539+00	.00000000	-.50000002+00	.86602539+00	.00000000	.30504511-01
14	2	-.64278765+00	.76604441+00	.00000000	-.64278765+00	.76604441+00	.00000000	.30504511-01
15	2	-.76604448+00	.64278758+00	.00000000	-.76604448+00	.64278758+00	.00000000	.30504511-01
16	2	-.86602543+00	.49999996+00	.00000000	-.86602543+00	.49999996+00	.00000000	.30504511-01
17	2	-.93969265+00	.34202008+00	.00000000	-.93969265+00	.34202008+00	.00000000	.30504511-01
18	2	-.98480777+00	.17364812+00	.00000000	-.98480777+00	.17364812+00	.00000000	.30504511-01
19	2	-.10000000+01	-.57620458-07	.00000000	-.10000000+01	-.57620458-07	.00000000	.30504511-01
20	2	-.98480774+00	-.17364823+00	.00000000	-.98480774+00	-.17364823+00	.00000000	.30504511-01
21	2	-.93969259+00	-.34202022+00	.00000000	-.93969259+00	-.34202022+00	.00000000	.30504511-01
22	2	-.86602537+00	-.50000006+00	.00000000	-.86602537+00	-.50000006+00	.00000000	.30504511-01
23	2	-.76604440+00	-.64278766+00	.00000000	-.76604440+00	-.64278766+00	.00000000	.30504511-01
24	2	-.64278754+00	-.76604450+00	.00000000	-.64278754+00	-.76604450+00	.00000000	.30504511-01
25	2	-.49999995+00	-.86602543+00	.00000000	-.49999995+00	-.86602543+00	.00000000	.30504511-01
26	2	-.34202007+00	-.93969265+00	.00000000	-.34202007+00	-.93969265+00	.00000000	.30504511-01
27	2	-.17364807+00	-.98480777+00	.00000000	-.17364807+00	-.98480777+00	.00000000	.30504511-01
28	2	.71529525-07	-.10000000+01	.00000000	.71529525-07	-.10000000+01	.00000000	.30504511-01
29	2	.17364827+00	-.98480774+00	.00000000	.17364827+00	-.98480774+00	.00000000	.30504511-01
30	2	.34202026+00	-.93969258+00	.00000000	.34202026+00	-.93969258+00	.00000000	.30504511-01
31	2	.50000007+00	-.86602536+00	.00000000	.50000007+00	-.86602536+00	.00000000	.30504511-01
32	2	.64278769+00	-.76604437+00	.00000000	.64278769+00	-.76604437+00	.00000000	.30504511-01
33	2	.76604453+00	-.64278751+00	.00000000	.76604453+00	-.64278751+00	.00000000	.30504511-01
34	2	.86602546+00	-.49999991+00	.00000000	.86602546+00	-.49999991+00	.00000000	.30504511-01
35	2	.93969266+00	-.34202003+00	.00000000	.93969266+00	-.34202003+00	.00000000	.30504511-01
36	2	.98480777+00	-.17364809+00	.00000000	.98480777+00	-.17364809+00	.00000000	.30504511-01

LOCAL FLUID-STRUCTURE TRANSFORMATION COEFFICIENTS:

NFLU	NSTR	
1	1	2
	.50000+00	.50000+00
2	3	4
	.50000+00	.50000+00
3	5	6
	.50000+00	.50000+00
4	7	8
	.50000+00	.50000+00
5	9	10
	.50000+00	.50000+00
6	11	12
	.50000+00	.50000+00
7	13	14
	.50000+00	.50000+00
8	15	16
	.50000+00	.50000+00
9	17	18
	.50000+00	.50000+00
10	19	20
	.50000+00	.50000+00

11	21	22
	.50000+00	.50000+00
12	23	24
	.50000+00	.50000+00
13	25	26
	.50000+00	.50000+00
14	27	28
	.50000+00	.50000+00
15	29	30
	.50000+00	.50000+00
16	31	32
	.50000+00	.50000+00
17	33	34
	.50000+00	.50000+00
18	35	36
	.50000+00	.50000+00
19	37	38
	.50000+00	.50000+00
20	39	40
	.50000+00	.50000+00
21	41	42
	.50000+00	.50000+00
22	43	44
	.50000+00	.50000+00
23	45	46
	.50000+00	.50000+00
24	47	48
	.50000+00	.50000+00
25	49	50
	.50000+00	.50000+00
26	51	52
	.50000+00	.50000+00
27	53	54
	.50000+00	.50000+00
28	55	56
	.50000+00	.50000+00
29	57	58
	.50000+00	.50000+00
30	59	60
	.50000+00	.50000+00
31	61	62
	.50000+00	.50000+00
32	63	64
	.50000+00	.50000+00
33	65	66
	.50000+00	.50000+00
34	67	68
	.50000+00	.50000+00
35	69	70
	.50000+00	.50000+00
36	71	72
	.50000+00	.50000+00

FLUID ELEMENT WETTED FREEDOM INDICATOR:

1	2	3	4	5	6	7	8	9	10
1	1	1	1	1	1	1	1	1	1

```
      11        12        13        14        15        16        17        18        19        20
       1         1         1         1         1         1         1         1         1         1

      21        22        23        24        25        26        27        28        29        30
       1         1         1         1         1         1         1         1         1         1

      31        32        33        34        35        36
       1         1         1         1         1         1
```

GENERALIZED FLUID AREAS:

```
        1          2          3          4          5          6          7          8          9         10
.30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01
       11         12         13         14         15         16         17         18         19         20
.30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01
       21         22         23         24         25         26         27         28         29         30
.30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01
       31         32         33         34         35         36
.30505-01  .30505-01  .30505-01  .30505-01  .30505-01  .30505-01
```

```
+++ @ ASG,AX     CYL*KSKY.
+++ @ USE     22,CYL*KSKY.
```

DIAGONAL STRUCTURAL MASS MATRIX:

```
        1          2          3          4          5          6          7          8          9         10
.11973-02  .11973-02  .11973-02  .00000     .00000     .00000     .11973-02  .11973-02  .11973-02  .00000
       11         12         13         14         15         16         17         18         19         20
.00000     .00000     .11973-02  .11973-02  .11973-02  .00000     .00000     .00000     .11973-02  .11973-02
       21         22         23         24         25         26         27         28         29         30
.11973-02  .00000     .00000     .00000     .11973-02  .11973-02  .11973-02  .00000     .00000     .00000
       31         32         33         34         35         36         37         38         39         40
.11973-02  .11973-02  .11973-02  .00000     .00000     .00000     .11973-02  .11973-02  .11973-02  .00000
       41         42         43         44         45         46         47         48         49         50
.00000     .00000     .11973-02  .11973-02  .11973-02  .00000     .00000     .00000     .11973-02  .11973-02
       51         52         53         54         55         56         57         58         59         60
.11973-02  .00000     .00000     .00000     .11973-02  .11973-02  .11973-02  .00000     .00000     .00000
       61         62         63         64         65         66         67         68         69         70
.11973-02  .11973-02  .11973-02  .00000     .00000     .00000     .11973-02  .11973-02  .11973-02  .00000
       71         72         73         74         75         76         77         78         79         80
.00000     .00000     .11973-02  .11973-02  .11973-02  .00000     .00000     .00000     .11973-02  .11973-02
       81         82         83         84         85         86         87         88         89         90
.11973-02  .00000     .00000     .00000     .11973-02  .11973-02  .11973-02  .00000     .00000     .00000
       91         92         93         94         95         96         97         98         99        100
.11973-02  .11973-02  .11973-02  .00000     .00000     .00000     .11973-02  .11973-02  .11973-02  .00000
      101        102        103        104        105        106        107        108        109        110
.00000     .00000     .11973-02  .11973-02  .11973-02  .00000     .00000     .00000     .11973-02  .11973-02
      111        112        113        114        115        116        117        118        119        120
.11973-02  .00000     .00000     .00000     .11973-02  .11973-02  .11973-02  .00000     .00000     .00000
      121        122        123        124        125        126        127        128        129        130
.11973-02  .11973-02  .11973-02  .00000     .00000     .00000     .11973-02  .11973-02  .11973-02  .00000
      131        132        133        134        135        136        137        138        139        140
.00000     .00000     .11973-02  .11973-02  .11973-02  .00000     .00000     .00000     .11973-02  .11973-02
      141        142        143        144        145        146        147        148        149        150
.11973-02  .00000     .00000     .00000     .11973-02  .11973-02  .11973-02  .00000     .00000     .00000
      151        152        153        154        155        156        157        158        159        160
.11973-02  .11973-02  .11973-02  .00000     .00000     .00000     .11973-02  .11973-02  .11973-02  .00000
```

161	162	163	164	165	166	167	168	169	170
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
171	172	173	174	175	176	177	178	179	180
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
181	182	183	184	185	186	187	188	189	190
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
191	192	193	194	195	196	197	198	199	200
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
201	202	203	204	205	206	207	208	209	210
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
211	212	213	214	215	216	217	218	219	220
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
221	222	223	224	225	226	227	228	229	230
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
231	232	233	234	235	236	237	238	239	240
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
241	242	243	244	245	246	247	248	249	250
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
251	252	253	254	255	256	257	258	259	260
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
261	262	263	264	265	266	267	268	269	270
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
271	272	273	274	275	276	277	278	279	280
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
281	282	283	284	285	286	287	288	289	290
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
291	292	293	294	295	296	297	298	299	300
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
301	302	303	304	305	306	307	308	309	310
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
311	312	313	314	315	316	317	318	319	320
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
321	322	323	324	325	326	327	328	329	330
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
331	332	333	334	335	336	337	338	339	340
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
341	342	343	344	345	346	347	348	349	350
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
351	352	353	354	355	356	357	358	359	360
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
361	362	363	364	365	366	367	368	369	370
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
371	372	373	374	375	376	377	378	379	380
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
381	382	383	384	385	386	387	388	389	390
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
391	392	393	394	395	396	397	398	399	400
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
401	402	403	404	405	406	407	408	409	410
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
411	412	413	414	415	416	417	418	419	420
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
421	422	423	424	425	426	427	428	429	430
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
431	432								
.00000	.00000								

STRUCTURAL GRID POINT NUMBERS ASSOCIATED WITH INTERNAL SEQUENCE NUMBERS:

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
61	62	63	64	65	66	67	68	69	70
71	72								
71	72								

GRID POINT AND FREEDOM NUMBER FOR EACH ROW OF STIFFNESS MATRIX:

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	21	22	23	24
11	12	13	14	15	16	17	18	19	20
25	26	31	32	33	34	35	36	41	42
21	22	23	24	25	26	27	28	29	30
43	44	45	46	51	52	53	54	55	56
31	32	33	34	35	36	37	38	39	40
61	62	63	64	65	66	71	72	73	74
41	42	43	44	45	46	47	48	49	50
75	76	81	82	83	84	85	86	91	92
51	52	53	54	55	56	57	58	59	60
93	94	95	96	101	102	103	104	105	106
61	62	63	64	65	66	67	68	69	70
111	112	113	114	115	116	121	122	123	124
71	72	73	74	75	76	77	78	79	80
125	126	131	132	133	134	135	136	141	142
81	82	83	84	85	86	87	88	89	90
143	144	145	146	151	152	153	154	155	156
91	92	93	94	95	96	97	98	99	100
161	162	163	164	165	166	171	172	173	174

101 175	102 176	103 181	104 182	105 183	106 184	107 185	108 186	109 191	110 192
111 193	112 194	113 195	114 196	115 201	116 202	117 203	118 204	119 205	120 206
121 211	122 212	123 213	124 214	125 215	126 216	127 221	128 222	129 223	130 224
131 225	132 226	133 231	134 232	135 233	136 234	137 235	138 236	139 241	140 242
141 243	142 244	143 245	144 246	145 251	146 252	147 253	148 254	149 255	150 256
151 261	152 262	153 263	154 264	155 265	156 266	157 271	158 272	159 273	160 274
161 275	162 276	163 281	164 282	165 283	166 284	167 285	168 286	169 291	170 292
171 293	172 294	173 295	174 296	175 301	176 302	177 303	178 304	179 305	180 306
181 311	182 312	183 313	184 314	185 315	186 316	187 321	188 322	189 323	190 324
191 325	192 326	193 331	194 332	195 333	196 334	197 335	198 336	199 341	200 342
201 343	202 344	203 345	204 346	205 351	206 352	207 353	208 354	209 355	210 356
211 361	212 362	213 363	214 364	215 365	216 366	217 371	218 372	219 373	220 374
221 375	222 376	223 381	224 382	225 383	226 384	227 385	228 386	229 391	230 392
231 393	232 394	233 395	234 396	235 401	236 402	237 403	238 404	239 405	240 406
241 411	242 412	243 413	244 414	245 415	246 416	247 421	248 422	249 423	250 424
251 425	252 426	253 431	254 432	255 433	256 434	257 435	258 436	259 441	260 442
261 443	262 444	263 445	264 446	265 451	266 452	267 453	268 454	269 455	270 456
271 461	272 462	273 463	274 464	275 465	276 466	277 471	278 472	279 473	280 474
281 475	282 476	283 481	284 482	285 483	286 484	287 485	288 486	289 491	290 492
291	292	293	294	295	296	297	298	299	300

493	494	495	496	501	502	503	504	505	506
301	302	303	304	305	306	307	308	309	310
511	512	513	514	515	516	521	522	523	524
311	312	313	314	315	316	317	318	319	320
525	526	531	532	533	534	535	536	541	542
321	322	323	324	325	326	327	328	329	330
543	544	545	546	551	552	553	554	555	556
331	332	333	334	335	336	337	338	339	340
561	562	563	564	565	566	571	572	573	574
341	342	343	344	345	346	347	348	349	350
575	576	581	582	583	584	585	586	591	592
351	352	353	354	355	356	357	358	359	360
593	594	595	596	601	602	603	604	605	606
361	362	363	364	365	366	367	368	369	370
611	612	613	614	615	616	621	622	623	624
371	372	373	374	375	376	377	378	379	380
625	626	631	632	633	634	635	636	641	642
381	382	383	384	385	386	387	388	389	390
643	644	645	646	651	652	653	654	655	656
391	392	393	394	395	396	397	398	399	400
661	662	663	664	665	666	671	672	673	674
401	402	403	404	405	406	407	408	409	410
675	676	681	682	683	684	685	686	691	692
411	412	413	414	415	416	417	418	419	420
693	694	695	696	701	702	703	704	705	706
421	422	423	424	425	426	427	428	429	430
711	712	713	714	715	716	721	722	723	724
431	432								
725	726								

FREEDOM/EQUATION CORRESPONDENCE TABLE:

	1	2	3	4	5	6	7	8	9	10
1	1	7	13	19	25	31	37	43	49	55
2	2	8	14	20	26	32	38	44	50	56
3	3	9	15	21	27	33	39	45	51	57
4	4	10	16	22	28	34	40	46	52	58
5	5	11	17	23	29	35	41	47	53	59
6	6	12	18	24	30	36	42	48	54	60
	11	12	13	14	15	16	17	18	19	20
1	61	67	73	79	85	91	97	103	109	115
2	62	68	74	80	86	92	98	104	110	116

3	63	69	75	81	87	93	99	105	111	117
4	64	70	76	82	88	94	100	106	112	118
5	65	71	77	83	89	95	101	107	113	119
6	66	72	78	84	90	96	102	108	114	120
	21	22	23	24	25	26	27	28	29	30
1	121	127	133	139	145	151	157	163	169	175
2	122	128	134	140	146	152	158	164	170	176
3	123	129	135	141	147	153	159	165	171	177
4	124	130	136	142	148	154	160	166	172	178
5	125	131	137	143	149	155	161	167	173	179
6	126	132	138	144	150	156	162	168	174	180
	31	32	33	34	35	36	37	38	39	40
1	181	187	193	199	205	211	217	223	229	235
2	182	188	194	200	206	212	218	224	230	236
3	183	189	195	201	207	213	219	225	231	237
4	184	190	196	202	208	214	220	226	232	238
5	185	191	197	203	209	215	221	227	233	239
6	186	192	198	204	210	216	222	228	234	240
	41	42	43	44	45	46	47	48	49	50
1	241	247	253	259	265	271	277	283	289	295
2	242	248	254	260	266	272	278	284	290	296
3	243	249	255	261	267	273	279	285	291	297
4	244	250	256	262	268	274	280	286	292	298
5	245	251	257	263	269	275	281	287	293	299
6	246	252	258	264	270	276	282	288	294	300
	51	52	53	54	55	56	57	58	59	60
1	301	307	313	319	325	331	337	343	349	355
2	302	308	314	320	326	332	338	344	350	356
3	303	309	315	321	327	333	339	345	351	357
4	304	310	316	322	328	334	340	346	352	358
5	305	311	317	323	329	335	341	347	353	359
6	306	312	318	324	330	336	342	348	354	360
	61	62	63	64	65	66	67	68	69	70
1	361	367	373	379	385	391	397	403	409	415
2	362	368	374	380	386	392	398	404	410	416
3	363	369	375	381	387	393	399	405	411	417
4	364	370	376	382	388	394	400	406	412	418
5	365	371	377	383	389	395	401	407	413	419
6	366	372	378	384	390	396	402	408	414	420
	71	72								
1	421	427								
2	422	428								
3	423	429								
4	424	430								
5	425	431								
6	426	432								

```
+++ ● ASG,T      UNIT20.        F4/    4/TRK/    256
+++ ● USE     20,UNIT20.
      ----------------------------
```

```
MASTER RECORD OF MATRIX STIF
----------------------------

MATRIX HEADER :   MTI     ROWS    COLS   SIZE-4
                000444     432     432      0
MTX ATTRIBUTES:          SINGLE SYMM   REAL    SKYLIN MULTBL

MAXMVR MVRSIZ   MBU MULROW   NMVR
   6    2688    448    6       6

 MVR      BLOCK EXTENT TABLE           RECORD ACCESS DIRECTORY
  #     F-COL    L-ROW    ROWS     LDI  DLOC(I)   DLOC(O)     SIZE
  1        1      132      132      20      37   00000045     2688
  2      121      258      126      20     133   00000205     2688
  3      241      378      120      20     229   00000345     2688
  4      361      420       42      20     325   00000505     2688
  5        1      426        6      20     421   00000645     2688
  6        1      432        6      20     517   00001005     2688

CHECK MDT

-------------------------------
MATRIX DESCRIPTOR TABLE (MDT)
-------------------------------

      MTRX  BLKCOM ADDRESSES           DEVICE DESCRIPTOR AREA              MISCELLANEOUS INPUT AREA          MATRIX HEADER
 PKT  NAME   HDR    BXT   RAD   LDI EXT-DEV-NAME TYPX OPTX   LIMIT REEL   VAL1  VAL2   VAL34     VAL56     MTI    ROWS  COLS
  1   STIF    1      5    16     0                 0    0       0          0     0    0.000     0.000    000444   432   432

----------------------------------------------------------------
VALUE RECORD     1 OF MATRIX  STIF    EASY HDR:  000444   432   432
----------------------------------------------------------------

MVR PREFIX.  SPAR    26    133   2298   2688

MVR HEADER:

       WORD  1      WORD  2      WORD  3      WORD  4      WORD  5      WORD  6      WORD  7      WORD  8      WORD  9      WORD 10
        STIF             1          292          432          432            0            1          132          132            0

       WORD 11      WORD 12      WORD 13      WORD 14      WORD 15      WORD 16      WORD 17      WORD 18      WORD 19      WORD 20
            0            0            0            0            0            0            0            0            0            0

       WORD 21      WORD 22      WORD 23      WORD 24      WORD 25      WORD 26
            0            0            0            0            0            0

MATRIX VALUES:
          COL 1        COL 2        COL 3        COL 4        COL 5        COL 6        COL 7        COL 8        COL 9        COL 10
DIAG  1.36189-02  8.86689-01  8.89374-01  2.30450-07  3.01072-05  3.04495-05  1.36189-02  8.86689-01  8.89374-01  2.30450-07
          COL 11       COL 12       COL 13       COL 14       COL 15       COL 16       COL 17       COL 18       COL 19       COL 20
DIAG  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01
          COL 21       COL 22       COL 23       COL 24       COL 25       COL 26       COL 27       COL 28       COL 29       COL 30
DIAG  8.89373-01  2.30448-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04496-05
```

```
        COL 31      COL 32      COL 33      COL 34      COL 35      COL 36      COL 37      COL 38      COL 39      COL 40
DIAG  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07

        COL 41      COL 42      COL 43      COL 44      COL 45      COL 46      COL 47      COL 48      COL 49      COL 50
DIAG  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01

        COL 51      COL 52      COL 53      COL 54      COL 55      COL 56      COL 57      COL 58      COL 59      COL 60
DIAG  8.89373-01  2.30448-07  3.01072-05  3.04495-05  1.36189-02  6.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04495-05

        COL 61      COL 62      COL 63      COL 64      COL 65      COL 66      COL 67      COL 68      COL 69      COL 70
DIAG  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07

        COL 71      COL 72      COL 73      COL 74      COL 75      COL 76      COL 77      COL 78      COL 79      COL 80
DIAG  3.01072-05  3.01496-05   .36189-02  8.86691-01  8.89373-01  2.30449-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01

        COL 81      COL 82      COL 83      COL 84      COL 85      COL 86      COL 87      COL 88      COL 89      COL 90
DIAG  8.89373-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04495-05

        COL 91      COL 92      COL 93      COL 94      COL 95      COL 96      COL 97      COL 98      COL 99      COL 100
DIAG  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07

       COL 101     COL 102     COL 103     COL 104     COL 105     COL 106     COL 107     COL 108     COL 109     COL 110
DIAG  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01

       COL 111     COL 112     COL 113     COL 114     COL 115     COL 116     COL 117     COL 118     COL 119     COL 120
DIAG  8.89373-01  2.30448-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04496-05

       COL 121     COL 122     COL 123     COL 124     COL 125     COL 126     COL 127     COL 128     COL 129     COL 130
DIAG  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07

       COL 131     COL 132
DIAG  3.01072-05  3.04496-05


 ------------------------------------------------------------
 VALUE RECORD     2 OF MATRIX  STIF   EASY HDR:  000444   432   432
 ------------------------------------------------------------

 MVR PREFIX:  SPAR    26    127   2313   2688

 MVR HEADER:

        WORD  1     WORD  2     WORD  3     WORD  4     WORD  5     WORD  6     WORD  7     WORD  8     WORD  9     WORD 10
         STIF             2         292         432         432           0         121         258         126           0

        WORD 11     WORD 12     WORD 13     WORD 14     WORD 15     WORD 16     WORD 17     WORD 18     WORD 19     WORD 20
              0           0           0           0           0           0           0           0           0           0

        WORD 21     WORD 22     WORD 23     WORD 24     WORD 25     WORD 26
              0           0           0           0           0           0

 MATRIX VALUES:

       COL 133     COL 134     COL 135     COL 136     COL 137     COL 138     COL 139     COL 140     COL 141     COL 142
DIAG  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07

       COL 143     COL 144     COL 145     COL 146     COL 147     COL 148     COL 149     COL 150     COL 151     COL 152
```

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DIAG   3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01

       COL 153     COL 154     COL 155     COL 156     COL 157     COL 158     COL 159     COL 160     COL 161     COL 162
DIAG   8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04495-05

       COL 163     COL 164     COL 165     COL 166     COL 167     COL 168     COL 169     COL 170     COL 171     COL 172
DIAG   1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07

       COL 173     COL 174     COL 175     COL 176     COL 177     COL 178     COL 179     COL 180     COL 181     COL 182
DIAG   3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01

       COL 183     COL 184     COL 185     COL 186     COL 187     COL 188     COL 189     COL 190     COL 191     COL 192
DIAG   8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05

       COL 193     COL 194     COL 195     COL 196     COL 197     COL 198     COL 199     COL 200     COL 201     COL 202
DIAG   1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07

       COL 203     COL 204     COL 205     COL 206     COL 207     COL 208     COL 209     COL 210     COL 211     COL 212
DIAG   3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04495-05  1.36159-02  8.86691-01

       COL 213     COL 214     COL 215     COL 216     COL 217     COL 218     COL 219     COL 220     COL 221     COL 222
DIAG   8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04495-05

       COL 223     COL 224     COL 225     COL 226     COL 227     COL 228     COL 229     COL 230     COL 231     COL 232
DIAG   1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07

       COL 233     COL 234     COL 235     COL 236     COL 237     COL 238     COL 239     COL 240     COL 241     COL 242
DIAG   3.01072-05  3.04495-05  1.36169-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01

       COL 243     COL 244     COL 245     COL 246     COL 247     COL 248     COL 249     COL 250     COL 251     COL 252
DIAG   8.89373-01  2.30449-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04495-05

       COL 253     COL 254     COL 255     COL 256     COL 257     COL 258
DIAG   1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05


   ----------------------------------------------------------------------------
   VALUE RECORD     3 OF MATRIX  STIF   EASY HDR:  C00444    432    432
   ----------------------------------------------------------------------------

   MVR PREFIX:  SPAR     26    121   2220   2688

   MVR HEADER:

         WORD  1     WORD  2     WORD  3     WORD  4     WORD  5     WORD  6     WORD  7     WORD  8     WORD  9     WORD 10
          STIF             3         292         432         432           0         241         378         120           0

         WORD 11     WORD 12     WORD 13     WORD 14     WORD 15     WORD 16     WORD 17     WORD 18     WORD 19     WORD 20
               0           0           0           0           0           0           0           0           0           0

         WORD 21     WORD 22     WORD 23     WORD 24     WORD 25     WORD 26
               0           0           0           0           0           0

   MATRIX VALUES:

       COL 259     COL 260     COL 261     COL 262     COL 263     COL 264     COL 265     COL 266     COL 267     COL 268
DIAG   1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07
```

```
      COL 269     COL 270     COL 271     COL 272     COL 273     COL 274     COL 275     COL 276     COL 277     COL 278
DIAG  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01

      COL 279     COL 280     COL 281     COL 282     COL 283     COL 284     COL 285     COL 286     COL 287     COL 288
DIAG  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05

      COL 289     COL 290     COL 291     COL 292     COL 293     COL 294     COL 295     COL 296     COL 297     COL 298
DIAG  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07

      COL 299     COL 300     COL 301     COL 302     COL 303     COL 304     COL 305     COL 306     COL 307     COL 308
DIAG  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01

      COL 309     COL 310     COL 311     COL 312     COL 313     COL 314     COL 315     COL 316     COL 317     COL 318
DIAG  8.89373-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04495-05

      COL 319     COL 320     COL 321     COL 322     COL 323     COL 324     COL 325     COL 326     COL 327     COL 328
DIAG  1.36189-02  8.86691-01  8.89373-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07

      COL 329     COL 330     COL 331     COL 332     COL 333     COL 334     COL 335     COL 336     COL 337     COL 338
DIAG  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01

      COL 339     COL 340     COL 341     COL 342     COL 343     COL 344     COL 345     COL 346     COL 347     COL 348
DIAG  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05

      COL 349     COL 350     COL 351     COL 352     COL 353     COL 354     COL 355     COL 356     COL 357     COL 358
DIAG  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04495-05  1.36189-02  8.86691-01  8.89373-01  2.30448-07

      COL 359     COL 360     COL 361     COL 362     COL 363     COL 364     COL 365     COL 366     COL 367     COL 368
DIAG  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01

      COL 369     COL 370     COL 371     COL 372     COL 373     COL 374     COL 375     COL 376     COL 377     COL 378
DIAG  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05


     -----------------------------------------------------------------
     VALUE RECORD    4 OF MATRIX  STIF   EASY HDR:  000444   432   432
     -----------------------------------------------------------------

     MVR PREFIX:  SPAR    26    43    795   2688

     MVR HEADER:

           WORD  1     WORD  2     WORD  3     WORD  4     WORD  5     WORD  6     WORD  7     WORD  8     WORD  9     WORD 10
            STIF             4         292         432         432           0         361         420          42           0

           WORD 11     WORD 12     WORD 13     WORD 14     WORD 15     WORD 16     WORD 17     WORD 18     WORD 19     WORD 20
                 0           0           0           0           0           0           0           0           0           0

           WORD 21     WORD 22     WORD 23     WORD 24     WORD 25     WORD 26
                 0           0           0           0           0           0

     MATRIX VALUES:

      COL 379     COL 380     COL 381     COL 382     COL 383     COL 384     COL 385     COL 386     COL 387     COL 388
DIAG  1.36189-02  8.86691-01  8.89372-01  2.30448-07  3.01072-05  3.04496-05  1.36189-02  8.86691-01  8.89372-01  2.30448-07
```

	COL 389	COL 390	COL 391	COL 392	COL 393	COL 394	COL 395	COL 396	COL 397	COL 398
DIAG	3.01072-05	3.04495-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01
	COL 399	COL 400	COL 401	COL 402	COL 403	COL 404	COL 405	COL 406	COL 407	COL 408
DIAG	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05
	COL 409	COL 410	COL 411	COL 412	COL 413	COL 414	COL 415	COL 416	COL 417	COL 418
DIAG	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07
	COL 419	COL 420								
DIAG	3.01072-05	3.04496-05								

VALUE RECORD 5 OF MATRIX STIF EASY HDR: 000444 432 432

MVR PREFIX: SPAR 26 7 2541 2688

MVR HEADER:

WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7	WORD 8	WORD 9	WORD 10
STIF	5	292	432	432	0	1	426	6	0
WORD 11	WORD 12	WORD 13	WORD 14	WORD 15	WORD 16	WORD 17	WORD 18	WORD 19	WORD 20
0	0	0	0	0	0	0	0	0	0
WORD 21	WORD 22	WORD 23	WORD 24	WORD 25	WORD 26				
0	0	0	0	0	0				

MATRIX VALUES:

	COL 421	COL 422	COL 423	COL 424	COL 425	COL 426
DIAG	1.36189-02	8.86689-01	8.89374-01	2.30450-07	3.01072-05	3.04495-05

VALUE RECORD 6 OF MATRIX STIF EASY HDR: 000444 432 432

MVR PREFIX: SPAR 26 7 2577 2688

MVR HEADER:

WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7	WORD 8	WORD 9	WORD 10
STIF	5	292	432	432	0	1	432	[illegible]	0
WORD 11	WORD 12	WORD 13	WORD 14	WORD 15	WORD 16	WORD 17	WORD 18	WORD 19	WORD 20
0	0	0	0	0	0	0	0	0	0
WORD 21	WORD 22	WORD 23	WORD 24	WORD 25	WORD 26				
0	0	0	0	0	0				

MATRIX VALUES:

COL 427	COL 428	COL 429	COL 430	COL 431	COL 432

```
DIAG   1.36189-02  8.36689-01  6.89374-01  2.30450-07  3.01072-05  3.04495-05


+++  @ FREE        UNIT20

+++  @ FREE        CYL*KSKY.

+++  @ ASG,T       UNIT20.              F4/     4/TRK/    256
+++  @ USE      20,UNIT20.
   DAA FORM OF STRUCTURAL MASS INVERSE MATRIX:

+++  @ ASG,T       UNIT18.,             F4/     4/TRK/    256
+++  @ USE      18,UNIT18.

      ----------------------------
      MASTER RECORD OF MATRIX TMIT
      ----------------------------

      MATRIX HEADER :   MTI    ROWS   COLS  SIZE-4
                      000444    36     36     0
      MTX ATTRIBUTES:         SINGLE SYMM   REAL   SKYLIN MULTBL

      MAXMVR MVRSIZ    MRU MULPGW   NMVR
          1    448     448     1      1

        MVR     BLOCK EXTENT TABLE          RECORD ACCESS DIRECTORY
         *    F-COL   L-ROW   ROWS     LDI  DLOC(I)   DLOC(O)   SIZE
         1      1      36      36       14     65   00000101    448

      ---------------------------------------------------------------
      VALUE RECORD     1 OF MATRIX  TMIT   EASY HDR:  000444    36    36
      ---------------------------------------------------------------

      MVR PREFIX:  AUGM    26     37     36    448

      MVR HEADER:

           WORD  1     WORD  2     WORD  3     WORD  4     WORD  5     WORD  6     WORD  7     WORD  8     WORD  9     WORD 10
            TMIT             1         292          36          36           0           1          36          36           0

           WORD 11     WORD 12     WORD 13     WORD 14     WORD 15     WORD 16     WORD 17     WORD 18     WORD 19     WORD 20
                 0           0           0           0           0           0           0           0           0           0

           WORD 21     WORD 22     WORD 23     WORD 24     WORD 25     WORD 26
                 0           0           0           0           0           0

      MATRIX VALUES:

              COL 1       COL 2       COL 3       COL 4       COL 5       COL 6       COL 7       COL 8       COL 9       COL 10
DIAG    3.86591-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01

             COL 11      COL 12      COL 13      COL 14      COL 15      COL 16      COL 17      COL 18      COL 19      COL 20
DIAG    3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01

             COL 21      COL 22      COL 23      COL 24      COL 25      COL 26      COL 27      COL 28      COL 29      COL 30
```

```
DIAG    3.88593-01  3.68593-01  3.88593-01  3.98593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.88593-01

          COL 31      COL 32      COL 33      COL 34      COL 35      COL 36
DIAG    3.88593-01  3.88593-01  3.88593-01  3.88593-01  3.89593-01  3.83591-01


  MATRIX VALUES:

                          1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3
      1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6

   1  +
   2    +
   3      +
   4        +
   5          +
   6            +
   7              +
   8                +
   9                  +
  10                    +
  11                      +
  12                        +
  13                          +
  14                            +
  15                              +
  16                                +
  17                                  +
  18                                    +
  19                                      +
  20                                        +
  21                                          +
  22                                            +
  23                                              +
  24                                                +
  25                                                  +
  26                                                    +
  27                                                      +
  28                                                        +
  29                                                          +
  30                                                            +
  31                                                              +
  32                                                                +
  33                                                                  +
  34                                                                    +
  35                                                                      +
  36                                                                        +


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+             A U X I L I A R Y   S T O R A G E   T A B L E               +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                                          +
+LDI EDN(Q*EFN) IFN      EC OP SEC CDLOC    NEXT  LIMIT      READ WRITTEN +
+ 14 CYL*PREP   16       36 UPR28     81      81  65536         0    1903 +
+ 16 UNIT18     18       36 T   28     4       4  16384        73      73 +
```

```
+ 18 UNIT20      20      36 T  28      72      72  16384      2196     2196 +
+                                                                          +
+                        3 ACTIVE DEVICES ( 0 FULL)                        +
+       0 TP-OPS,       18 WRITES,       66 READS,      24231 WORDS XFD    +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

+++  @ FREE        UNIT18.

+++  @ ASG,AX      CYL*DAAM.
+++  @ USE     12,CYL*DAAM.

   COMBINED STRUCTURAL AND FLUID MASS MATRIX:

+++  @ ASG,T       UNIT18..            F4/     4/TRK/     256
+++  @ USE     18,UNIT18.

     ----------------------------
     MASTER RECORD OF MATRIX DFDS
     ----------------------------

     MATRIX HEADER :   MTI    ROWS   COLS  SIZE-4
                    000144     36     36     0
     MTX ATTRIBUTES:          SINGLE SYMM   REAL    SKYLIN MULTBL

     MAXMVR MVRSIZ    MRU MULROW    NMVR
        3     448     448     1       3

       MVR      BLOCK EXTENT TABLE          RECORD ACCESS DIRECTORY
        #    F-COL    L-ROW    ROWS      LDI   DLOC(I)   DLOC(O)     SIZE
        1        1       23      23       14       83   00000123      448
        2        1       33      10       14       99   00000143      448
        3        1       36       3       14      115   00000163      448

     -----------------------------------------------------------------------
     VALUE RECORD     1 OF MATRIX  DFDS   EASY HDR:  000444     36     36
     -----------------------------------------------------------------------

     MVR PREFIX:  AUGM     26     24    276    448

     MVR HEADER:

            WORD  1     WORD  2     WORD  3     WORD  4     WORD  5     WORD  6     WORD  7     WORD  8     WORD  9     WORD 10
             DFDS             1     2[illegible]2          36          36           0           1          23          23           0

            WORD 11     WORD 12     WORD 13     WORD 14     WORD 15     WORD 16     WORD 17     WORD 18     WORD 19     WORD 20
                  0           0           0           0           0           0           0           0           0           0

            WORD 21     WORD 22     WORD 23     WORD 24     WORD 25     WORD 26
                  0           0           0           0           0           0

     MATRIX VALUES:

             COL 1       COL 2       COL 3       COL 4       COL 5       COL 6       COL 7       COL 8       COL 9       COL 10
   DIAG  6.59490-01  6.59492-01  6.59491-01  6.59492-01  6.59493-01  6.59492-01  6.59491-01  6.59491-01  6.59192-01  6.59491-01

            COL 11      COL 12      COL 13      COL 14      COL 15      COL 16      COL 17      COL 18      COL 19      COL 20
```

```
DIAG   6.59491-01  6.59493-01  6.59492-01  6.59492-01  6.59492-01  6.59492-01  6.59491-01  6.59493-01  6.59492-01  6.59493-01

         COL 21      COL 22      COL 23
DIAG   6.59492-01  6.59493-01  6.59491-01

-----------------------------------------------------------------
VALUE RECORD    2 OF MATRIX  DFDS   EASY HDR:  000444   36    36
-----------------------------------------------------------------

MVR PREFIX:  AUGM    26    11   285   448

MVR HEADER:
   WORD  1    WORD  2    WORD  3    WORD  4    WORD  5    WORD  6    WORD  7    WORD  8    WORD  9    WORD 10
    DFDS            2        292         36         36          0          1         33         10          0
   WORD 11    WORD 12    WORD 13    WORD 14    WORD 15    WORD 16    WORD 17    WORD 18    WORD 19    WORD 20
         0          0          0          0          0          0          0          0          0          0
   WORD 21    WORD 22    WORD 23    WORD 24    WORD 25    WORD 26
         0          0          0          0          0          0

MATRIX VALUES:
         COL 24      COL 25      COL 26      COL 27      COL 28      COL 29      COL 30      COL 31      COL 32      COL 33
DIAG   6.59492-01  6.59493-01  6.59491-01  6.59491-01  6.59491-01  [illegible]  6.59491-01  [illegible]  [illegible]  6.59492-01

-----------------------------------------------------------------
VALUE RECORD    3 OF MATRIX  DFDS   EASY HDR:  000444   36    36
-----------------------------------------------------------------

MVR PREFIX:  AUGM    26     4   105   448

MVR HEADER:
   WORD  1    WORD  2    WORD  3    WORD  4    WORD  5    WORD  6    WORD  7    WORD  8    WORD  9    WORD 10
    DFDS            3        292         36         36          0          1         36          3          0
   WORD 11    WORD 12    WORD 13    WORD 14    WORD 15    WORD 16    WORD 17    WORD 18    WORD 19    WORD 20
         0          0          0          0          0          0          0          0          0          0
   WORD 21    WORD 22    WORD 23    WORD 24    WORD 25    WORD 26
         0          0          0          0          0          0

MATRIX VALUES:
         COL 34      COL 35      COL 36
DIAG   6.59491-01  6.59491-01  6.59491-01

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+         A U X I L I A R Y    S T O R A G E    T A B L E          +
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

```
+
+LDI EDN(Q*EFN) IFN     EC OP SEC CDLOC    NEXT  LIMIT      READ WRITTEN +
+ 10 CYL*DAAM    12      36 AX 28      47     128  65536      1296       0 +
+ 14 CYL*PREP    16      36 UPR28     131     131  65536         0    3268 +
+ 16 UNIT18      18      36 T  28      28      28  16384       778     778 +
+ 18 UNIT20      20      36 T  28      72      72  16384      4768    3492 +
+                                                                         +
+                      4 ACTIVE DEVICES ( 0 FULL)                         +
+       0 TP-OPS,      95 WRITES,      145 READS,      32190 WORDS XFD    +
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

+++  @ FREE       UNIT18.

+++  @ FREE       UNIT20.

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+          A U X I L I A R Y    S T O R A G E    T A B L E                +
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                                         +
+LDI EDN(Q*EFN) IFN     EC OP SEC CDLOC    NEXT  LIMIT      READ WRITTEN +
+ 10 CYL*DAAM    12      36 AX 28      47     128  65536      1296       0 +
+ 14 CYL*PREP    16      36 UPR28       9     131  65536         0    3510 +
+                                                                         +
+                      2 ACTIVE DEVICES ( 0 FULL)                         +
+       0 TP-OPS,      95 WRITES,      145 READS,      32432 WORDS XFD    +
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

+++  @ FREE       CYL*PREP.

- - - - - - - - - - - - - - - - - - - - - - - - - - - -
      SUMMARY OF DATA STORED ON PERMANENT FILE
           ***   CYL*PREP              ***
- - - - - - - - - - - - - - - - - - - - - - - - - - - -
RECORD     RECORD DESCRIPTION       SECTOR     NUMBER
 SET                               LOCATION   OF WORDS
- - - - - - - - - - - - - - - - - - - - - - - - - - - -

  1     FILE LIBRARY DATA              0         242

  2     FLUID GEOMETRY AND             9         540
        TRANSFORMATION DATA

  3     GENERALIZED FLUID AREAS       29          36

  4     FREEDOM EQUATION              31         432
        CORRESPONDENCE TABLE

  5     DIAGONAL STRUCTURAL           47         432
        MASS INV

  6     SKYPUL MMR AND MVR FOR        63
        DAA STRUCTURAL MASS INV

  7     SKYPUL MMR AND MVR FOR        81
        DAA VIRTUAL MASS INV
```

APPENDIX C

USER INFORMATION FOR THE TIME INTEGRATION PROCESSOR TIMINT

This appendix includes a copy of the users manual, and a sample input deck and subsequent output for the infinite cylindrical shell problem presented in Section 4.

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                              T I M I N T

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      THIS FUNCTIONAL COMPONENT OF THE UNDERWATER SHOCK ANALYSIS CODE
      CONDUCTS A STEP-BY-STEP DIRECT NUMERICAL TIME INTEGRATION OF THE
      GOVERNING EQUATIONS OF SUBMERGED STRUCTURES EXPOSED TO SPHERICAL
      SHOCK WAVES OF ARBITRARY PRESSURE PROFILE AND SOURCE LOCATION. THE
      FLUID EQUATIONS UTILIZE THE WELL-KNOWN DOUBLY ASYMPTOTIC
      APPROXIMATION (DAA) WHILE THE STRUCTURE ITSELF MAY BE TREATED BY A
      VARIETY OF LINEAR OR NONLINEAR PROGRAM MODULES THAT CARRY OUT THE
      SPATIAL ANALYSIS AT EACH TIME STEP. THE CODE USES THE STAGGERED
      SOLUTION PROCEDURE WHEREIN THE STRUCTURAL RESPONSE EQUATIONS AND
      THE FLUID RESPONSE EQUATIONS ARE SOLVED SEPARATELY AT EACH TIME
      STEP THROUGH EXTRAPOLATION OF THE TERMS WHICH COUPLE THE TWO
      SYSTEMS

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      THIS PROGRAM WAS DEVELOPED AND CODED BY JOHN A. DERUNTZ, JR.
      OF LOCKHEED MISSILES AND SPACE CO. RESEARCH LABS IN PALO ALTO
      CALIFORNIA. PLEASE CONSULT WITH AUTHOR BEFORE MAKING CHANGES
      AND ALSO REPORT ANY MALFUNCTIONS OR PROBLEMS. WRITE IN CARE OF
      LOCKHEED PALO ALTO RESEARCH LABORATORY, BLDG 205, DEPT 52-33
      3251 HANOVER ST., PALO ALTO, CALIF., 94304 OR CALL 415-493-4411
      EXTS. 45069 OR 45133.                              SEPTEMBER, 1980

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

                         M A X I M U M     V A L U E S

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      MAXIMUM NUMBER OF INPUT PRESSURE DATA POINTS:

                        INFINITE FLUID  . . . . . . . . . . . . . . .   4 0 2

                        FREE SURFACE PROBLEM  . . . . . . . . . . . .   2 0 1

      MAXIMUM NUMBER OF CUBIC SPLINE TIME POINTS:

                        INFINITE FLUID  . . . . . . . . . . . . . . .   1 0 2

                        FREE SURFACE  ROBLEM  . . . . . . . . . . . .     5 1

      MAXIMUM NUMBER OF DIFFERENT TIME STEP SIZES   . . . . . . . . .     1 0

      MAXIMUM NUMBER OF PREVIOUS RESPONSE FILES   . . . . . . . . . .       9

      MAXIMUM NUMBER OF TRANSIENT RESPONSE DISPLAYS . . . . . . . . .   1 0 0

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

                     R U N    T I M E    I N F O R M A T I O N

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THE FOLLOWING INFORMATION IS PROVIDED FOR THE ESTIMATION OF CPU
TIME IN SECONDS TO WHICH MUST BE ADDED INPUT/OUTPUT CHARGES.
CORE-BLOCK TIME, EXECUTIVE REQUESTS, FILE CHARGES, ETC. THE RULE
TO FOLLOW IS TO ESTIMATE CPU TIME AND THEN INCREASE THIS TO ARRIVE
AT AN APPROXIMATE SYSTEM CHARGE ESTIMATE. FOR SMALL PROBLEMS THE
SYSTEM CHARGES CAN EASILY DOMINATE AND A LARGE FACTOR WOULD HAVE
TO BE APPLIED TO THE RUN TIME COMPUTED BELOW. FOR FAIRLY LARGE
PROBLEMS (2500 DOF) THIS FACTOR DROPS DOWN TO ABOUT TWO (2) FOR
UNIVAC OPERATION

THE ESTIMATES FOR STRUCTURAL FACTORIZATION AND ADVANCEMENT TIMES
GIVEN BELOW DO NOT APPLY TO THE USA-STAGS SYSTEM. PLEASE CONSULT A
STAGS MANUAL

DEFINITION OF VARIABLES REQUIRED FOR RUN TIME COMPUTATION:

     NSTEP     NUMBER OF TIME STEPS

     NTINC     NUMBER OF DIFFERENT TIME STEP INCREMENTS

     NDISP     NUMBER OF DEGREES OF FREEDOM FOR WHICH TRANSIENT
               RESPONSE HISTORIES ARE TO BE DISPLAYED AT CONCLUSION
               OF RUN

     NSFR      NUMBER OF DEGREES OF FREEDOM OF STRUCTURAL SYSTEM

     NFLU      NUMBER OF DEGREES OF FREEDOM OF FLUID SYSTEM

     BAVE      AVERAGE HALF BAND WIDTH OF STRUCTURAL STIFFNESS
               MATRIX

     BRMS      ROOT MEAN SQUARE HALF BAND WIDTH OF STRUCTURAL
               STIFFNESS MATRIX, USE AVERAGE HALF BAND WIDTH IF
               THIS QUANTITY IS NOT READILY AVAILABLE

     TCPU      TOTAL CENTRAL PROCESSING UNIT TIME REQUIRED FOR
               LISTED ITEMS BELOW

               TCPU = TPRE + NTINC*(TFS+TFF) + NSTEP*(TAS+TAF) + TDISP

     TPRE      CPU TIME SPENT ON PRE-PROCESSING BEFORE TIME
               INTEGRATION COMMENCES

               TPRE = 1000.*CS*(NSFR+NFLU)

     TFS       TIME REQUIRED TO FACTOR STRUCTURAL EQUATION SYSTEM

               TFS = CS*NSFR*BRMS**2/2.

     TAS       TIME REQUIRED FOR ADVANCEMENT OF ONE TIME STEP FOR
               STRUCTURAL SYSTEM

               TAS = 3.*CS*NSFR*BAVE

     TFF       TIME REQUIRED TO FACTOR FLUID EQUATION SYSTEM

               TFF = CS*NFLU**3/6.
```

```
        TAF       TIME REQUIRED FOR ADVANCEMENT OF ONE TIME STEP FOR
                  FLUID SYSTEM

                  TAF = CS*NFLU**2

        TDISP     CPU TIME SPENT ON DISPLAY OF RESPONSE HISTORIES

                  TDISP = 500.*CS*NSTEP*NDISP

        CS        UNIT OPERATION CONSTANT IN SECONDS, CONSISTING OF A
                  FLOATING ADDITION, A FLOATING MULTIPLY, AND INDEXING

                  V A L U E S    O F    C O N S T A N T    C S
                  - - - - - -    - -    - - - - - - - -    - -

                                 O P E R A T I N G    S Y S T E M

                  PRECISION     UNIVAC        UNIVAC         CDC
                                 1108          1110          6600

                    SINGLE     5.5X10-6      3.2X10-6      1.5X10-6

                    DOUBLE     9.0X10-6      4.5X10-6       - - -

                  AT THIS TIME THE CODE OPERATES ONLY IN SINGLE
                  PRECISION

      IN ADDITION TO BILLABLE CHARGES DUE TO EXECUTION OF THIS CODE
      THERE WILL PROBABLY BE A DAILY CHARGE FOR PERMANENT FILE STORAGE.
      RESPONSE AND RESTART FILES CREATED BY THIS CODE CAN BE EXTREMELY
      LENGTHY HENCE SUCH OUTPUT FROM LARGE RUNS SHOULD BE TRANSFERRED TO
      TAPE AT THE EARLIEST OPPORTUNITY TO MINIMIZE THESE CHARGES

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 W A R N I N G    F R O M    T H E    P R O G R A M M E R    G E N E R A L

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      THIS CODE CONTAINS THE SPECIAL INGREDIENT DMGASP NOT FOUND IN
      OTHER BRANDS. DMGASP IS A DATA MANAGEMENT UTILITY MODULE THAT
      WILL ACTIVATE AND DEACTIVATE ALL AUXILIARY STORAGE DATA FILES
      REFERENCED BY THE CODE. HENCE THE NAMES OF SUCH FILES SHOULD NOT
      APPEAR ON ANY CONTROL CARDS IN THE RUN STREAM WHICH MIGHT NORMALLY
      ACTIVATE AND DEACTIVATE THE FILES. THE USER IS ALSO CAUTIONED THAT
      PREVIOUSLY CREATED FILES MUST ALREADY BE RESIDENT IN THE SYSTEM
      BEFORE THE RUN IS INITIATED. IF A FILE HAS BEEN ROLLED-OUT TO TAPE
      DMGASP WILL ATTEMPT TO HAVE THE FILE ROLLED-IN EVERY 15 SECONDS
      FOR UP TO 6 MINUTES ON THE UNIVAC 1100-EXEC 8 OPERATING SYSTEM.
      IF AN EXISTING DATA FILE HAS NOT BEEN REFERENCED FOR SOME TIME IT
      IS THEREFORE GOOD POLICY TO SIMPLY ACTIVATE AND DEACTIVATE THE
      FILE BEFORE EXECUTION OF THIS CODE. IF THE USER ATTEMPTS TO CREATE
      A NEW DATA FILE WITH A NAME WHICH IS ALREADY ASSIGNED TO AN
      EXISTING FILE, THE UNIVAC VERSION OF DMGASP WILL MODIFY THE NAME
      OF THE FILE GENERATED BY THIS RUN TO AVOID ANY CONFLICT. FILE NAME
      DUPLICATION WILL CAUSE NO PROBLEM ON THE CDC SCOPE OPERATING
      SYSTEM AS SCOPE WILL SIMPLY CATALOG A NEW CYCLE OF THE SAME FILE.
```

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        ON THE OTHER HAND THE CDC NOS SYSTEM IS SIMILAR TO UNIVAC IN THIS
        REGARD AND THE RUN WILL ABORT SINCE THE NAME-CHANGING FEATURE OF
        DMGASP HAS NOT BEEN IMPLEMENTED FOR NOS. QUALIFIER*FILENAME IS THE
        REQUIRED INPUT DATA FORMAT FOR ALL UNIVAC PERMANENT FILE NAMES.
        ON CDC SCOPE, THE QUALIFIER IS INTERPRETED AS THE USERS ID. WHICH
        IN MOST INSTALLATIONS CAN BE SELECTED ALMOST ARBITRARILY. ON CDC
        NOS, THE QUALIFIER IS INTERPRETED AS THE USERS CATALOG NUMBER.
        WHICH IS USUALLY PRESCRIBED BY THE INSTALLATION. A CYCLE NUMBER
        CAN ALSO BE APPENDED TO GIVE THE FORM QUALIFIER*FILENAME(CYCLE)
        ON CDC SCOPE

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                     P R O G R A M     S I Z E

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        ALL ARRAYS REFERRENCED IN THIS CODE THAT ARE PROBLEM DEPENDENT
        RESIDE IN BLANK COMMON. THE SIZE OF BLANK COMMON IS DETERMINED BY
        A PARAMETER STATEMENT IN THE MAIN PROGRAM FOR THE UNIVAC 1100-OS
        VERSION, HENCE A RECOMPILATION IS NECESSARY TO INCREASE OR
        DECREASE CORE ALLOCATION. IN THE CDC 6600 VERSION RECOMPILATION IS
        UNNECESSARY AS THE LENGTH OF BLANK COMMON IS SET BY A FIELD LENGTH
        REQUEST IN THE CONTROL CARD DECK

  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

        D E F I N I T I O N    O F    I N P U T    P A R A M E T E R S

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        INPUT VARIABLE NAMES GIVEN BELOW ARE GENERALLY THOSE WHICH ARE
        ALSO USED IN THE CODING AND THE VARIABLE TYPES CORRESPOND TO
        STANDARD FORTRAN USAGE:

                      A   -   ALPHANUMERIC
                      E   -   FLOATING POINT
                      F   -   FIXED POINT
                      I   -   INTEGER
                      L   -   LOGICAL

        --------     ----                   -----------
        VARIABLE     TYPE                   DESCRIPTION
        --------     ----                   -----------

        PRLNAM        A       NAME OF PRE-PROCESSED MASS STORAGE FILE
                              CONTAINING ALL FLUID AND STRUCTURE DATA
                              THAT DOES NOT DEPEND UPON THE SHOCK INPUT
                              AND TIME INTEGRATION PARAMETERS

        POSNAM        A       NAME OF MASS STORAGE FILE AVAILABLE FOR
                              POST-PROCESSING WHICH CONTAINS SYSTEM
                              RESPONSES

        STRNEW        A       LEAVE BLANK FOR NORMAL USAGE. OTHERWISE
                              THIS IS THE NAME OF A DIFFERENT STRUCTURAL
                              STIFFNESS MATRIX FILE THAT IS TO BE USED
                              IN THE TIME INTEGRATION RUN RATHER THAN
```

```
                                THE ONE USED IN THE AUGMAT PROCESSOR. THE
                                ONLY CONDITIONS UNDER WHICH THIS ABNORMAL
                                CASE CAN BE USED ARE WHEN THE STRUCTURE
                                AND ITS MASS ARE THE SAME AS BEFORE. BUT
                                ITS ELASTIC CONSTANTS ARE DIFFERENT AS
                                OFTEN OCCURS IN PARAMETER STUDIES. IN SUCH
                                CASES AUGMAT NEED NOT BE RERUN

RESNAM          A               NAME OF MASS STORAGE FILE THAT CONTAINS
                                INFORMATION FOR RESTARTING THE TRANSIENT
                                RESPONSE ANALYSIS

WRTNAM          A               NAME OF MASS STORAGE FILE UPON WHICH
                                RESTART DATA IS TO BE WRITTEN. IF LEFT
                                BLANK THEN RESTART DATA WILL BE WRITEN ON
                                THE FILE DENOTED BY RESNAM

XC, YC, ZC      E.F             CARTESIAN COORDINATES OF THE LOCATION OF
                                SPHERICAL CHARGE IN FLUID MESH SYSTEM

SX, SY, SZ      E.F             CARTESIAN COORDINATES OF THE CHARGE
                                STANDOFF POINT IN THE FLUID MESH SYSTEM.
                                THIS IS THE POINT ON THE STRUCTURE THAT IS
                                CLOSEST TO THE CHARGE. THE INTEGRATION
                                PROCESS STARTS AT TIME EQUAL TO ZERO WITH
                                THE SPHERICAL WAVE JUST TOUCHING THE
                                STRUCTURE AT THIS POINT ASSOCIATED WITH
                                THE MINIMUM DISTANCE TO THE CHARGE

EXPWAV          L               TRUE IF THE INCIDENT PRESSURE PULSE IS
                                EXPRESSED IN THE FORM OF AN EXPONENTIALLY
                                DECAYING FUNCTION. OTHERWISE FALSE

SPLINE          L               TRUE IF THE INCIDENT PRESSURE PULSE IS
                                DESCRIBED BY A CUBIC SPLINE FUNCTION. CARE
                                SHOULD ALWAYS BE TAKEN WITH THE CHOICE OF
                                INPUT DATA POINTS SINCE THIS ALGORITH WILL
                                PRODUCE A CONTINUOUS FUNCTION THAT CAN
                                OSCILLATE WILDLY AROUND AREAS OF RAPID
                                CHANGE. IN SUCH CASES IT IS IMPORTANT TO
                                CLUSTER DATA POINTS IN THESE AREAS

JPHIST          I               NUMBER OF INCIDENT PRESSURE HISTORY DATA
                                POINTS. SEE ABOVE FOR MAXIMUM NUMBER
                                ALLOWED BY CORE ALLOCATION

DTHIST          E.F             TIME INTERVAL ASSOCIATED WITH ANY TWO
                                SUCCESSIVE INCIDENT PRESSURE HISTORY DATA
                                POINTS

PNORM           E.F             CONSTANT MULTIPLICATIVE FACTOR TO BE
                                APPLIED TO THE INPUT PRESSURE HISTORY DATA
                                POINTS

PHIST           E.F             INCIDENT PRESSURE HISTORY DATA POINTS. THE
                                VALUES USED IN THE TIME INTEGRATION
                                PROCESS ARE THE PRODUCT OF PHIST AND PNORM
                                TO ALLOW FOR THE POSSIBILITY THAT THE
```

		INPUT DATA MAY HAVE BEEN EXPERIMENTALLY OBTAINED AT A POINT WHICH IS NOT EQUAL TO SC ABOVE. PNORM MUST THEREFORE REFLECT THE 1/R SCALING DIFFERENCE BETWEEN SC AND THE LOCATION OF THE PRESSURE SENSOR DURING THE PULSE CHARACTERIZATION EXPERIMENT. IF THE INCIDENT PRESSURE GOES TO ZERO AT SOME POINT AND REMAINS THERE THEN DATA NEED ONLY BE PROVIDED FOR THAT TIME SPAN AND THE CODE WILL AUTOMATICALLY ENSURE THAT THE INCIDENT PRESSURE REMAINS ZERO THEREAFTER. WHEN RESTARTING THE TRANSIENT ANALYSIS THE REQUIRED INCIDENT PRESSURE DATA IS IDENTICAL TO THAT USED IN THE INITIAL RUN. IF SPLINE IS FALSE THEN THE PRESSURE HISTORY DATA MUST BE EQUALLY SPACED IN TIME WITH THE INCREMENT DTHIST. IF SPLINE IS TRUE THE PRESSURE HISTORY DATA CAN BE UNEQUALLY SPACED ACCORDING TO DATA PROVIDED IN TIMES (SEE BELOW). WHEN USING THE SPLINE CAPABILITY THE LAST PRESSURE DATA POINT MUST BE ZERO SO THAT THE CODE CAN AUTOMATICALLY GENERATE ZERO PRESSURES BEYOND THAT POINT. OTHERWISE AN OUT-OF-RANGE ERROR EXIT WILL BE TAKEN
PZERO	E.F	PEAK VALUE OF PRESSURE FOR EXPONENTIALLY DECAYING INCIDENT PULSE
DECAY	E.F	DECAY TIME FOR EXPONENTIALLY DECAYING INCIDENT PRESSURE PULSE. THIS IS THE TIME IT TAKES FOR THE PRESSURE TO DROP TO 1/E (ABOUT .36788) OF ITS PEAK VALUE
TIMES	E.F	TIME VALUES ASSOCIATED WITH UNEQUALLY SPACED INCIDENT PRESSURE HISTORY VALUES
NTINT	I	NUMBER OF TIME STEP SIZES TO BE USED IN THE INTEGRATION PROCESS. SEE ABOVE FOR MAXIMUM NUMBER ALLOWED BY CORE ALLOCATION
STRTIM	E.F	THE STARTING TIME AT WHICH ANY PARTICULAR STEP SIZE IS TO BE USED UNTIL IT IS EITHER SUPERCEEDED BY ANOTHER STEP SIZE OR. THE ENTIRE TRANSIENT ANALYSIS HAS BEEN COMPLETED
DELTIM	E.F	TIME STEP SIZE ASSOCIATED WITH STRTIM ABOVE
FINTIM	E.F	TIME AT WHICH THE PRESENT ANALYSIS IS TO BE TERMINATED
NSAVER	I	FREQUENCY OF SAVING SYSTEM RESPONSES ON PERMANENT FILE POSNAM. NSAVER EXPRESSED IN NUMBER OF TIME STEPS
NRESET	I	FREQUENCY OF SAVING RESTART INFORMATION

```
                                    ON PERMANENT FILE RESNAM OR WRTNAM. NRESET
                                    IS EXPRESSED IN NUMBER OF TIME STEPS

          LOCBEG        I           LOCATION IN POSNAM FILE WHERE RESPONSES
                                    FROM CURRENT RUN ARE TO BE PLACED. THIS
                                    LOCATION IS MEASURED EITHER IN SECTORS
                                    (28 WORDS) ON UNIVAC SYSTEMS OR PHYSICAL
                                    RECORD UNITS (PRU OF 64 WORDS) ON CDC
                                    HARDWARE. A ZERO VALUE IS THE DESIGNATION
                                    OF THE BEGINNING OF THE FILE FOR EITHER
                                    SYSTEM IN THIS CODE. IF LOCBEG = 0. A NEW
                                    PERMANENT FILE IS ASSIGNED FOR THE RUN
                                    WITH THE NAME DENOTED BY POSNAM. OTHERWISE
                                    POSNAM IS TAKEN TO BE AN EXISTING FILE.
                                    UNDER RESTART CONDITIONS THE APPROPRIATE
                                    VALUE OF LOCBEG IS ASCERTAINED FROM
                                    OUTPUT GENERATED DURING PRECEEDING RUNS

          LOCRES        I           LOCATION IN PERMANENT FILE RESNAM WHERE
                                    RESTART DATA IS TO BE FOUND. SEE LOCBEG
                                    FOR DEFINITION OF LOCATION. SET EQUAL TO
                                    ZERO IF CURRENT RUN IS NOT A RESTART.
                                    OTHERWISE APPROPRIATE VALUE OF LOCRES IS
                                    ASCERTAINED FROM OUTPUT GENERATED DURING
                                    PRECEEDING RUNS

          LOCWRT        I           LOCATION IN PERMANENT FILE RESNAM OR
                                    WRTNAM WHERE NEW RESTART DATA GENERATED IN
                                    THE CURRENT RUN IS TO BE WRITTEN. SEE
                                    LOCBEG FOR DEFINITION OF LOCATION. IF
                                    WRTNAM HAS BEEN LEFT BLANK (SEE ABOVE) THE
                                    RESTART DATA IS WRITTEN ON THE SAME FILE
                                    AS THAT CONTAINING THE DATA USED TO
                                    RESTART THE CURRENT RUN. IN SUCH A CASE IT
                                    IS IMPORTANT THAT LOCWRT BE CAREFULLY
                                    CHOSEN SO THAT PREVIOUS DATA IS NOT
                                    INADVERTENTLY OVERWRITTEN. AN APPROPRIATE
                                    VALUE CAN BE FOUND FROM OUTPUT GENERATED
                                    FROM PRECEEDING RUNS. IF LOCWRT = ZERO. A
                                    NEW PERMANENT FILE IS ASSIGNED FOR THE RUN
                                    WITH THE NAME DENOTED BY WRTNAM. OTHERWISE
                                    WRTNAM IS TAKEN TO BE AN EXISTING FILE

          FORWRT        L           TRUE IF PERMANENT FILE DENOTED BY POSNAM
                                    IS TO BE CREATED USING UNFORMATTED FORTRAN
                                    WRITE. OTHERWISE FILE WILL BE CREATED BY
                                    DIRECT TRANSFER USING THE DATA MANAGEMENT
                                    SYSTEM DMGASP

          DISPLA        L           TRUE IF SELECTED TRANSIENT RESPONSE
                                    HISTORIES ARE TO BE DISPLAYED. OTHERWISE
                                    FALSE

          NPREVT        I           NUMBER OF TIME STEPS PREVIOUSLY COMPUTED
                                    WITH RESPONSES SAVED IN PERMANENT FILE
                                    DENOTED BY POSNAM. NPREVT WILL BE NONZERO
                                    ONLY FOR RESTART RUNS BUT IT CAN BE ZERO
                                    UNDER RESTART CONDITIONS IF POSNAM DENOTES
```

		A NEW RESPONSE FILE. THE USE OF NPREVT ENSURES THAT ANY TRANSIENT RESPONSE DISPLAY MADE IN CONJUNCTION WITH THE TIME INTEGRATION RUN WILL INCLUDE THE ENTIRE HISTORY AVAILABLE FROM THAT FILE AND NOT JUST THE PORTION COMPUTED DURING THE CURRENT RUN. IF POSNAM CONTAINS THE COMPLETE TRANSIENT SOLUTION BACK TO TIME ZERO THEN NPREVT MUST BE THE NUMBER OF TIME STEPS PLUS ONE TO ACCOUNT FOR THE FACT THAT THE INITIAL CONDITIONS APPEAR IN THE FIRST RECORD. IF THIS RUN IS THE VERY FIRST OF A PARTICULAR SHOCK ANALYSIS THEN NPREVT WILL BE ZERO
NPREVF	I	NUMBER OF RESPONSE FILES FROM PREVIOUS RUNS THAT MAKE UP THE DESIRED TRANSIENT ANALYSIS DISPLAY. DO NOT ADD IN THE CURRENT RUN AS THIS IS DONE BY THE CODE. NPREVF PRESENTLY CANNOT EXCEED NINE (9)
NTIMES	I	THE NUMBER OF RESPONSE RECORDS THAT ARE STORED IN ANY PARTICULAR RESPONSE FILE. THESE MUST BE ORDERED CHRONOLOGICALLY FOR INPUT. NTIMES WILL GENERALLY BE THE NUMBER OF TIME STEPS MADE DURING THE TIME THE FILE WAS CREATED EXCEPT IF THE FILE GOES BACK TO TIME EQUAL TO ZERO. IN THIS CASE NTIMES IS EQUAL TO THE NUMBER OF TIME STEPS PLUS ONE TO ACCOUNT FOR THE FIRST RECORD THAT CONTAINS THE INITIAL CONDITIONS
XVPNAM	A	NAMES OF PREVIOUS RESPONSE FILES THAT MAKE UP A CONTINUOUS SET OF TRANSIENT DATA, ORDERED CHRONOLOGICALLY. DO NOT INCLUDE POSNAM IN THIS LIST
LISTRE	L	TRUE IF TRANSIENT RESPONSE HISTORIES ARE TO BE LISTED IN TABULAR FORM. OTHERWISE FALSE
PRTPLT	L	TRUE IF PRINTER PLOTS ARE TO BE GENERATED FOR TRANSIENT RESPONSE HISTORIES. OTHERWISE FALSE
NWETHS	I	NUMBER OF STRUCTURAL HISTORIES (EITHER DISPLACEMENTS OR VELOCITIES) TO BE DISPLAYED FOR WHICH THE APPROPRIATE STRUCTURAL FREEDOMS CAN BE IDENTIFIED INTERNALLY THROUGH THE FREEDOM/EQUATION CORRESPONDENCE TABLE. ALL STRUCTURAL NODES WHICH PARTICIPATE IN THE FLUID-STRUCTURE TRANSFORMATION WILL FALL INTO THIS CATEGORY AS WELL AS ANY OTHERS WHOSE GRID POINT COORDIATES WERE ENTERED AS DATA FOR

```
                                   THE FLUID MASS PROCESSOR

         NORYHS        I           NUMBER OF STRUCTURAL HISTORIES (EITHER
                                   DISPLACEMENTS OR VELOCITIES) TO BE
                                   DISPLAYED FOR WHICH THE APPROPRIATE
                                   STRUCTURAL FREEDOMS CANNOT BE IDENTIFIED
                                   INTERNALLY THROUGH THE FREEDOM/EQUATION
                                   CORRESPONDENCE TABLE. DRY STRUCTURE NODE
                                   POINTS CAN FALL INTO THIS CATEGORY IF THE
                                   USER DID NOT INCLUDE THEM IN THE DATA
                                   STREAM FOR THE FLUID MASS PROCESSOR. IN
                                   THIS CASE ONE MUST IDENTIFY THE INTERNAL
                                   SEQUENCE NUMBER APPROPRIATE TO THE DESIRED
                                   DEGREE OF FREEDOM BY A MYSTICAL PROCESS
                                   WHICH INVOLVES THE INTIMATE KNOWLEDGE OF
                                   THE ELIMINATION ORDER AND ANY REDUCTION
                                   OF THE NUMBER OF ACTIVE FREEDOMS DUE TO
                                   THE APPLICATION OF CONSTRAINTS. MORAL OF
                                   THE STORY - RUN ALL STRUCTURAL GRID POINTS
                                   THROUGH THE FLUID MASS PROCESSOR EVEN IF
                                   THEY NEVER GET WET

         NUMSET        I           NUMBER OF DATA SETS USED TO DEFINE
                                   RESPONSE DISPLAYS FOR SEVERAL DEGREES OF
                                   FREEDOM THAT DIFFER BY A CONSTANT
                                   INCREMENT. THIS FEATURE CAN BE USED TO
                                   SIMPLIFY INPUT DATA TO SHOW A NUMBER OF
                                   TRANSIENT RESULTS AT DIFFERENT PLACES
                                   ALONG A GENERATOR OF A CYLINDER OR. AROUND
                                   THE CIRCUMFERENCE AT ANY AXIAL STATION

         NODOUT        I           EXTERNAL INDENTIFICATION NUMBER OF
                                   STRUCTURAL NODE FOR WHICH A TIME HISTORY
                                   DISPLAY IS DESIRED

         NFROUT        I           STRUCTURAL DEGREE OF FREEDOM NUMBER FOR
                                   WHICH A TIME HISTORY DISPLAY IS DESIRED

         NEQHST        I           INTERNAL SEQUENCE NUMBER DETERMINED BY
                                   HAND FOR STRUCTURAL DEGREES OF FREEDOM
                                   WHICH ARE TO BE DISPLAYED AND ARE NOT
                                   INCLUDED IN THE FREEDOM/EQUATION
                                   CORRESPONDENCE TABLE FOR REASONS KNOWN
                                   ONLY TO THE USER
         NODFIR        I           FIRST OF SEVERAL EQUALLY INCREMENTED NODE
                                   NUMBERS AT WHICH OUTPUT IS DESIRED

         NODLAS        I           LAST OF SEVERAL EQUALLY INCREMENTED NODE
                                   NUMBERS AT WHICH OUTPUT IS DESIRED

         NODINC        I           INCREMENT TO BE APPLIED IN ASSIGNING NODE
                                   NUMBERS FOR OUTPUT


         NPREHS        I           NUMBER OF FLUID PRESSURE HISTORIES TO BE
                                   DISPLAYED

         NEQHPR        I           FLUID CONTROL POINT NUMBER FOR WHICH A
```

```
                                TIME HISTORY DISPLAY IS DESIRED FOR THE
                                TOTAL PRESSURE

         SCALEF        L        TRUE IF MULTIPLICATIVE CONSTANT FACTORS
                                ARE TO BE APPLIED TO THE DISPLAYED VALUES
                                OF THE STRUCTURAL DISPLACEMENTS AND
                                VELOCITIES. TOTAL FLUID PRESSURES AND/OR
                                TIME. OTHERWISE FALSE. SUCH FACTORS ARE
                                NOT APPLIED TO THE PERMANENT FILES
                                CONTAINING THE RESPONSE HISTORIES

         RESFAC        E.F      MULTIPLICATIVE LENGTH CONVERSION FACTOR TO
                                BE APPLIED TO THE DISPLAYED VALUES OF THE
                                STRUCTURAL DISPLACEMENT AND VELOCITY
                                HISTORIES

         PREFAC        E.F      MULTIPLICATIVE PRESSURE CONVERSION FACTOR
                                TO BE APPLIED TO THE DISPLAYED VALUES OF
                                THE TOTAL PRESSURE HISTORIES

         TIMFAC        E.F      MULTIPLICATIVE TIME CONVERSION FACTOR TO
                                BE APPLIED TO THE DISPLAYED VALUES OF THE
                                TIME AXIS FOR ALL THE TRANSIENT RESPONSE
                                HISTORIES

    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

                  I N P U T     D A T A     C A R D     D E C K

    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

         ALL INPUT DATA EXCEPT ALPHANUMERIC DATA MUST BE RIGHT JUSTIFIED
         IN EIGHT (8) COLUMN FIELDS WHICH CAN OCCUPY THE ENTIRE CARD.
         ALPHANUMERIC DATA MUST BE LEFT JUSTIFIED IN TWENTY (20) COLUMN
         FIELDS. FILE NAME PLUS QUALIFIER IS CURRENTLY RESTRICTED TO
         EIGHTEEN (18) CHARACTERS FOR UNIVAC OPERATION WHILE NINETEEN (19)
         CHARACTERS MAY BE USED FOR CDC OPERATION

         GENERAL PROBLEM DEFINITION (SUBROUTINE INPDAT):
         -----------------------------------------------

         72 COLUMN ALPHNUMERIC TITLE
         PRENAM              POSNAM              STRNEW
         RESNAM              WRTNAM
         XC       YC       ZC
         SX       SY       SZ
         EXPWAV   SPLINE
         JPHIST
         PNORM

         IF SPLINE = .FALSE. READ THE FOLLOWING CARD

         DTHIST

         IF EXPWAV = .FALSE. READ THE FOLLOWING CARDS

         PHIST(I), I=1,JPHIST

```

```
IF EXPWAV = .TRUE. READ THE FOLLOWING CARD

PZERO   DECAY

CUBIC SPLINE INCIDENT PRESSURE HISTORY DATA (SUBROUTINE CSPRES):
----------------------------------------------------------------

IF SPLINE = .TRUE. READ THE FOLLOWING CARDS

TIMES(I), I=1,JPHIST
PHIST(I), I=1,JPHIST

GENERAL PROBLEM DEFINITION (SUBROUTINE INPDAT):
-----------------------------------------------

NTINT
STRTIM  DELTIM          )
   .       .            )    TOTAL = NTINT
   .       .            )
FINTM
NSAVER  NRESET
LOCBEG  LOCRES  LOCWRT
FORWRT

POST PROCESSING (SUBROUTINE POSTRE):
------------------------------------

DISPLA

IF DISPLA = .FALSE. THIS TERMINATES THE INPUT DATA DECK

NPREVT  NPREVF

IF NPREVF NOT = 0 READ THE FOLLOWING CARDS

NTIMES(I), I=1,NPREVF
XVPNAM(I), I=1,NPREVF

POST PROCESSING (SUBROUTINE RESDSP):
------------------------------------

LISTRE  PRTPLT

POST PROCESSING (SUBROUTINE STRDSP):
------------------------------------

NWETHS  NDRYHS  NUMSET                      )
NODOUT  NFROUT          )                   )
   .       .            )    TOTAL = NWETHS )
   .       .            )                   )
NODOUT  NFROUT  NEQHST  )                   )   THIS SET FOR
   .       .       .    )    TOTAL = NDRYHS )
   .       .       .    )                   )   DISPLACEMENTS
                                            )
IF NUMSET = 0 OMIT THE FOLLOWING CARD       )
                                            )
NFROUT  NODFIR  NODLAS  NODINC              )
```

```
NWETHS  NDRYHS  NUMSET                          )
NODOUT  NFROUT             )                    )
   .       .               )   TOTAL = NWETHS   )
   .       .               )                    )
NODOUT  NFROUT  NEQHST     )                    )   THIS SET FOR
   .       .       .       )   TOTAL = NDRYHS   )
   .       .       .       )                    )   VELOCITIES
                                                )
IF NUMSET = 0 OMIT THE FOLLOWING CARD           )
                                                )
NFROUT  NODFIR  NODLAS  NODINC                  )

POST PROCESSING (SUBROUTINE RESDSP):
------------------------------------

NPREHS  NUMSET
NEQHPR                     )
   .                       )   TOTAL = NPREHS
   .                       )

IF NUMSET = 0 OMIT THE FOLLOWING CARD

NODFIR  NODLAS  NODINC

POST PROCESSING (SUBROUTINE FILBUF):
------------------------------------

SCALEF

IF SCALEF = .TRUE. READ THE FOLLOWING CARD

RESFAC  PREFAC  TIMFAC
```

The following discussion is provided as an aid to user understanding of the sample output that is included here.

First, the amount of storage required for the run given in the output refers solely to the blank common that is set in the main program, UNWASH. An error exit is taken if insufficient storage is available and the user must see that more is provided either by a recompilation on UNIVAC 1100-OS or by a field length request on CDC.

Sector address information for the response and restart files that is listed at various places in the output is extremely important for subsequent restart runs.

The next item needing discussion is the transient response tabular listings. The desired responses are displayed in matrix form so that each row contains the entire history of a particular degree of freedom except for the first row which is time. Each column therefore contains the instantaneous values of the complete set of response variables desired at a particular time. Each row is identified by the structural or fluid node and its degree of freedom. The letters D, V, and P stand for displacement, velocity and pressure, respectively.

Although printer plots of the transient response results can be displayed as part of the run such output has been deferred to the post-processing phase in Appendix D for this sample problem.

```
TIMINT RUN FOR INFINITE CYLINDER SIMULATION
CYL*PREP            CYL*POST
CYL*REST
  10000.      0.       0.
      1.      0.       0.
      F       F
      2
     1.
    50.
     1.       1.
      3
     0.     .025
     1.     .05
     2.      .1
     5.
      1      30
      0       0        0
      F
      T
      0       0
      T       F
      2       0
     19       1
     19       2
      4       0
      1       1
     19       1
     19       2
     37       1
      3
      1
     10
     19
      F
```

@XQT

@ADD,P CYLINTDAT

TIMINT RUN FOR INFINITE CYLINDER SIMULATION

```
+++  @ ASG,AX     CYL*PREP.
+++  @ USE      16,CYL*PREP.
```

THIS IS A DAA1 RUN

CHARGE LOCATION DATA:

XC = .10000000+05

YC = .00000000

ZC = .00000000

SC = .99990000+04

PRESSURE HISTORY DATA: DTHIST = .50000000+02

1	2
.10000+01	.10000+01

TIME STEP DATA:

N	TS	DT
1	.00000	.25000-01
2	.10000+01	.50000-01
3	.20000+01	.10000+00
4	.50000+01	

INCIDENT PRESSURE AND PARTICLE VELOCITY:

	1	2	3	4	5	6	7	8	9	10
T	.00000	.41667+00	.83333+00	.12500+01	.16667+01	.20833+01	.25000+01	.29167+01	.33333+01	.37500+01
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10000+01	.10000+01	.10001+01	.10001+01	.10002+01	.10002+01	.10002+01	.10003+01	.10003+01	.10004+01

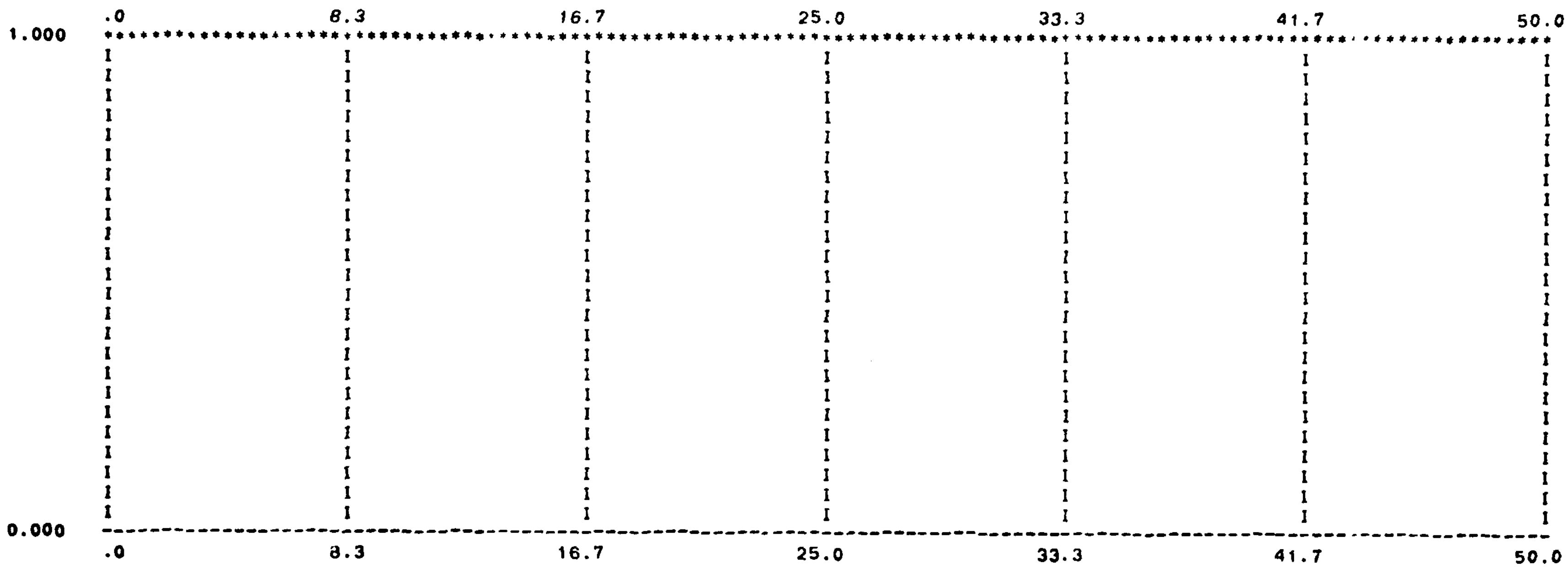
	11	12	13	14	15	16	17	18	19	20
T	.41667+01	.45833+01	.50000+01	.54167+01	.58333+01	.62500+01	.66667+01	.70833+01	.75000+01	.79167+01
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10004+01	.10005+01	.10005+01	.10005+01	.10006+01	.10006+01	.10007+01	.10007+01	.10008+01	.10008+01

	21	22	23	24	25	26	27	28	29	30
T	.83333+01	.87500+01	.91667+01	.95833+01	.10000+02	.10417+02	.10833+02	.11250+02	.11667+02	.12083+02
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10008+01	.10009+01	.10009+01	.10010+01	.10010+01	.10010+01	.10011+01	.10011+01	.10012+01	.10012+01

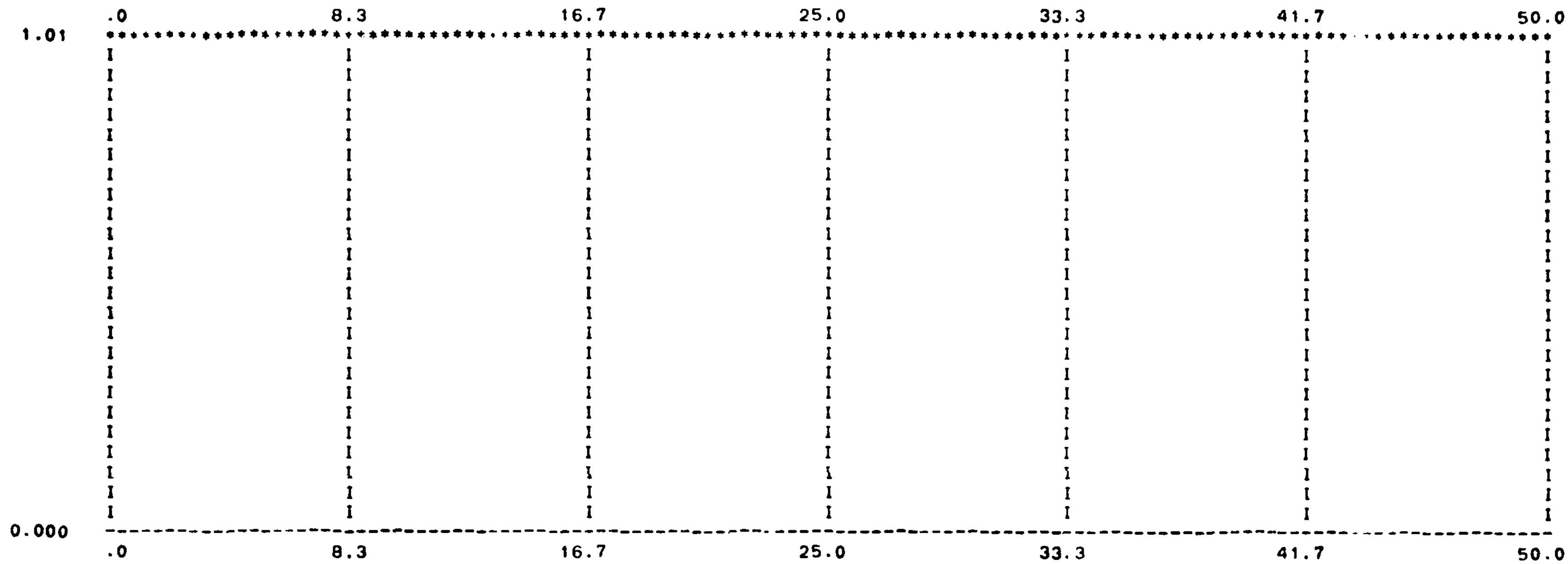
	31	32	33	34	35	36	37	38	39	40
T	.12500+02	.12917+02	.13333+02	.13750+02	.14167+02	.14583+02	.15000+02	.15417+02	.15833+02	.16250+02
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10015+01	.10016+01	.10016+01

	41	42	43	44	45	46	47	48	49	50
T	.16667+02	.17083+02	.17500+02	.17917+02	.18333+02	.18750+02	.19167+02	.19583+02	.20000+02	.20417+02
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10017+01	.10017+01	.10018+01	.10018+01	.10018+01	.10019+01	.10019+01	.10020+01	.10020+01	.10020+01
	51	52	53	54	55	56	57	58	59	60
T	.20833+02	.21250+02	.21667+02	.22083+02	.22500+02	.22917+02	.23333+02	.23750+02	.24167+02	.24583+02
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10021+01	.10021+01	.10022+01	.10022+01	.10023+01	.10023+01	.10023+01	.10024+01	.10024+01	.10025+01
	61	62	63	64	65	66	67	68	69	70
T	.25000+02	.25417+02	.25833+02	.26250+02	.26667+02	.27083+02	.27500+02	.27917+02	.28333+02	.28750+02
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10025+01	.10025+01	.10026+01	.10026+01	.10027+01	.10027+01	.10028+01	.10028+01	.10028+01	.10029+01
	71	72	73	74	75	76	77	78	79	80
T	.29167+02	.29583+02	.30000+02	.30417+02	.30833+02	.31250+02	.31667+02	.32083+02	.32500+02	.32917+02
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10029+01	.10030+01	.10030+01	.10030+01	.10031+01	.10031+01	.10032+01	.10032+01	.10033+01	.10033+01
	81	82	83	84	85	86	87	88	89	90
T	.33333+02	.33750+02	.34167+02	.34583+02	.35000+02	.35417+02	.35833+02	.36250+02	.36667+02	.37083+02
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10033+01	.10034+01	.10034+01	.10035+01	.10035+01	.10035+01	.10036+01	.10036+01	.10037+01	.10037+01
	91	92	93	94	95	96	97	98	99	100
T	.37500+02	.37917+02	.38333+02	.38750+02	.39167+02	.39583+02	.40000+02	.40417+02	.40833+02	.41250+02
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10038+01	.10038+01	.10038+01	.10039+01	.10039+01	.10040+01	.10040+01	.10040+01	.10041+01	.10041+01
	101	102	103	104	105	106	107	108	109	110
T	.41667+02	.42083+02	.42500+02	.42917+02	.43333+02	.43750+02	.44167+02	.44583+02	.45000+02	.45417+02
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10042+01	.10042+01	.10043+01	.10043+01	.10043+01	.10044+01	.10044+01	.10045+01	.10045+01	.10045+01
	111	112	113	114	115	116	117	118	119	120
T	.45833+02	.46250+02	.46667+02	.47083+02	.47500+02	.47917+02	.48333+02	.48750+02	.49167+02	.49583+02
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10046+01	.10046+01	.10047+01	.10047+01	.10048+01	.10048+01	.10048+01	.10049+01	.10049+01	.10050+01
	121									
T	.50000+02									
P	.10000+01									
V	.10050+01									

INCIDENT PRESSURE PULSE:



INCIDENT PARTICLE VELOCITY:




```
+++ @ ASG,T       UNIT20.,          F4/     4/TRK/    256
+++ @ USE      20,UNIT20.

+++ @ ASG,UP      CYL*POST.,         F/     4/TRK/   1024
+++ @ USE      12,CYL*POST.

+++ @ ASG,UP      CYL*REST.,         F/     4/TRK/   1024
+++ @ USE      14,CYL*REST.

+++ @ ASG,AX      CYL*KSKY.
+++ @ USE      22,CYL*KSKY.

    12536 WORDS OF STORAGE REQUIRED FOR THIS RUN

+++ @ ASG,T       UNIT19.,          F4/     4/TRK/    256
+++ @ USE      19,UNIT19.

+++ @ ASG,T       UNIT13.,          F4/     4/TRK/    256
+++ @ USE      13,UNIT13.

+++ @ ASG,T       UNIT18.,          F4/     4/TRK/    256
+++ @ USE      18,UNIT18.

+++ @ FREE        UNIT13.
```

```
RESTART DATA FOR T =    .750000 WRITTEN AT LOCATION     0 ON PERMANENT FILE CYL*REST

POST PROCESSING RESPONSE FILE LOCATION IS  1054

+++  @ ASG,T       UNIT13.            F4/     4/TRK/    256
+++  @ USE      13,UNIT13.

+++  @ FREE        UNIT13.
RESTART DATA FOR T =   2.000000 WRITTEN AT LOCATION   121 ON PERMANENT FILE CYL*REST

POST PROCESSING RESPONSE FILE LOCATION IS  2074

+++  @ ASG,T       UNIT13.            F4/     4/TRK/    256
+++  @ USE      13,UNIT13.

+++  @ FREE        UNIT13.
RESTART DATA FOR T =   5.000000 WRITTEN AT LOCATION   242 ON PERMANENT FILE CYL*REST

POST PROCESSING RESPONSE FILE LOCATION IS  3094

SECTOR ADDRESS OF RESPONSE FILE CYL*POST          AT EXIT IS  3094

SECTOR ADDRESS OF RESTART FILE CYL*REST           AT EXIT IS   363

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+           A U X I L I A R Y    S T O R A G E    T A B L E            +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                                      +
+LDI EQN(Q*EFN) IFN     EC OP SEC CDLOC    NEXT  LIMIT      READ WRITTEN +
+ 10 CYL*POST   12     36 UP 28    3094    3094  65536         0   82173 +
+ 12 CYL*REST   14     36 UP 28     363     363  65536         0    9939 +
+ 14 CYL*PREP   16     36 AX 28      63     192  65536    246582       0 +
+ 16 UNIT18     18     36 T  28      96     576  16384   2733696   48384 +
+ 17 UNIT19     19     36 T  28      16      48  16384    405888    4032 +
+ 18 UNIT20     20     36 T  28      48      48  16384    120528  117936 +
+ 20 CYL*KSKY   22     36 AX 28     613     640  16384   1500367       0 +
+                                                                      +
+                    7 ACTIVE DEVICES ( 0 FULL)                        +
+       0 TP-OPS,    588 WRITES,    3329 READS,    5272117 WORDS XFD   +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

+++  @ FREE        CYL*POST.

+++  @ FREE        CYL*REST.

+++  @ ASG,AX      CYL*POST.
+++  @ USE      12,CYL*POST.
```

+++ ● FREE CYL*POST.

TRANSIENT RESPONSE HISTORIES:

	1	2	3	4	5	6	7	8	9	10
T	-.00000	.25000-01	.50000-01	.75000-01	.10000+00	.12500+00	.15000+00	.17500+00	.200[illegible]+00	.22500+00
19/1 D	.00000	-.12761-05	-.77264-05	-.23805-04	-.51117-04	-.87290-04	-.12606-03	-.15937-03	-.177[illegible]-03	-.16999-03
19/2 D	.00000	.29228-08	.29661-07	.15183-06	.53060-06	.14430-05	.32943-05	.66559-05	.124[illegible]-04	.22567-04
1/1 V	.00000	-.27877+00	-.73079+00	-.10601+01	-.12958+01	-.14633+01	-.15886+01	-.16791+01	-.174[illegible]+01	-.17960+01
19/1 V	.00000	-.10209-03	-.41417-03	-.87189-03	-.13331-02	-.15735-02	-.15354-02	-.11297-02	-.319[illegible]-03	.91873-03
19/2 V	.00000	.23382-06	.19032-05	.78680-05	.22434-04	.50555-04	.97550-04	.17138-03	.291[illegible]-03	.51760-03
37/1 V	.00000	-.50333-04	-.20308-03	-.42464-03	-.63468-03	-.75274-03	-.72185-03	-.51061-03	-.104[illegible]-03	.50251-03
1/0 P	.11765+00	.16367+01	.12214+01	.89728+00	.67575+00	.53058+00	.43638+00	.37575+00	.337[illegible]+00	.31373+00
10/0 P	-.00000	.64336-03	.13301-02	.15851-02	.12747-02	.52082-03	-.51119-03	-.16906-02	-.295[illegible]-02	-.42580-02
19/0 P	-.00000	.31716-03	.64859-03	.76221-03	.59607-03	.21714-03	-.29775-03	-.87822-03	-.149[illegible]-02	-.21342-02

	11	12	13	14	15	16	17	18	19	20
T	.25000+00	.27500+00	.30000+00	.32500+00	.35000+00	.37500+00	.40000+00	.42500+00	.450[illegible]+00	.47500+00
19/1 D	-.12615-03	-.35159-04	.11411-03	.33643-03	.64977-03	.10815-02	.16707-02	.24753-02	.356[illegible]-02	.50395-02
19/2 D	.41628-04	.81028-04	.16719-03	.35596-03	.75415-03	.15462-02	.30189-02	.55728-02	.970[illegible]-02	.15952-01
1/1 V	-.18332+01	-.18612+01	-.18823+01	-.18983+01	-.19104+01	-.19195+01	-.19264+01	-.19317+01	-.193[illegible]+01	-.19396+01
19/1 V	.25191-02	.46899-02	.72752-02	.10487-01	.14581-01	.19954-01	.27183-01	.37025-01	.502[illegible]-01	.67682-01
19/2 V	.10072-02	.21448-02	.47452-02	.10354-01	.21501-01	.41850-01	.75960-01	.12835[illegible]	.2021[illegible]+00	.29761+00
37/1 V	.13032-02	.22781-02	.34103-02	.46867-02	.60899-02	.75938-02	.91686-02	.10790-01	.124[illegible]-01	.14098-01
1/0 P	.30092+00	.29575+00	.29564+00	.29901+00	.30488+00	.31268+00	.32169+00	.33134+00	.341[illegible]+00	.35102+00
10/0 P	-.54641-02	-.64911-02	-.73547-02	-.78323-02	-.75970-02	-.60506-02	-.26067-02	.30941-02	.119[illegible]-01	.24376-01
19/0 P	-.27400-02	-.32973-02	-.38438-02	-.43843-02	-.48969-02	-.53416-02	-.57534-02	-.61409-02	-.651[illegible]-02	-.68896-02

	21	22	23	24	25	26	27	28	29	30
T	.50000+00	.52500+00	.55000+00	.57500+00	.60000+00	.62500+00	.65000+00	.67500+00	.700[illegible]+00	.72500+00
19/1 D	.70653-02	.95736-02	.12845-01	.16899-01	.21781-01	.27510-01	.34078-01	.41466-01	.496[illegible]-01	.58644-01
19/2 D	.24803-01	.36592-01	.51414-01	.69104-01	.89292-01	.11152+00	.13541+00	.16071+00	.187[illegible]+00	.21562+00
1/1 V	-.19426+01	-.19451+01	-.19472+01	-.19493+01	-.19516+01	-.19542+01	-.19570+01	-.19598+01	-.196[illegible]+01	-.19652+01
19/1 V	.89585-01	.11588+00	.14576+00	.17841+00	.21322+00	.24610+00	.27932+00	.31170+00	.343[illegible]+00	.37543+00
19/2 V	.41049+00	.53259+00	.65316+00	.76205+00	.85297+00	.92555+00	.98502+00	.10396+01	.109[illegible]+01	.11596+01
37/1 V	.15750-01	.17375-01	.18947-01	.20447-01	.21863-01	.23199-01	.24440-01	.25660-01	.269[illegible]-01	.28458-01
1/0 P	.36076+00	.37048+00	.38003+00	.38915+00	.39768+00	.40660+00	.41298+00	.42007+00	.427[illegible]+00	.43381+00
10/0 P	.40160-01	.59176-01	.80392-01	.10242+00	.12397+00	.14417+00	.16208+00	.17787+00	.191[illegible]+00	.20401+00
19/0 P	-.72684-02	-.76077-02	-.79129-02	-.81959-02	-.84432-02	-.86077-02	-.86684-02	-.85010-02	-.796[illegible]-02	-.68364-02

	31	32	33	34	35	36	37	38	39	40
T	.75000+00	.77500+00	.80000+00	.82500+00	.85000+00	.87500+00	.90000+00	.92500+00	.950[illegible]+00	.97500+00
19/1 D	.68435-01	.79052-01	.90521-01	.10288+00	.11618+00	.13018+00	.14584+00	.16225+00	.179[illegible]+00	.19636+00
19/2 D	.24545+00	.27694+00	.31002+00	.34455+00	.38038+00	.41747+00	.45584+00	.49557+00	.536[illegible]+00	.57912+00
1/1 V	-.19678+01	-.19706+01	-.19738+01	-.19775+01	-.19816+01	-.19857+01	-.19896+01	-.19933+01	-.199[illegible]0+01	-.20010+01
19/1 V	.40791+00	.44139+00	.47670+00	.51273+00	.55131+00	.59236+00	.63650+00	.67630+00	.689[illegible]+00	.67376+00
19/2 V	.12265+01	.12927+01	.13537+01	.14083+01	.14587+01	.15066+01	.15611+01	.16166+01	.167[illegible]+01	.17239+01
37/1 V	.30600-01	.33505-01	.38012-01	.45062-01	.55364-01	.70015-01	.89069-01	.11547+00	.147[illegible]+00	.18575+00
1/0 P	.44629+00	.44623+00	.45150+00	.45616+00	.46047+00	.46409+00	.46897+00	.47324+00	.477[illegible]+00	.48084+00
10/0 P	.21516+00	.22489+00	.23217+00	.23709+00	.23971+00	.23946+00	.23666+00	.28211+00	.417[illegible]+00	.47750+00
19/0 P	-.47568-02	-.12409-02	.43532-02	.12819-01	.25010-01	.41741-01	.63651-01	.91016-01	.123[illegible]+00	.16047+00

	41	42	43	44	45	46	47	48	49	50
T	.10000+01	.10500+01	.11000+01	.11500+01	.12000+01	.12500+01	.13000+01	.13500+01	.140[illegible]0+01	.14500+01
19/1 D	.21251+00	.23950+00	.25837+00	.26882+00	.27205+00	.27066+00	.26424+00	.25579+00	.245[illegible]0+00	.23483+00
19/2 D	.62279+00	.71326+00	.80753+00	.90532+00	.10059+01	.11076+01	.12087+01	.13071+01	.14010+01	.14893+01
1/1 V	-.20054+01	-.20147+01	-.20257+01	-.20326+01	-.20425+01	-.20539+01	-.20660+01	-.20774+01	-.208[illegible]3+01	-.20996+01
19/1 V	.61802+00	.46164+00	.29319+00	.12472+00	.44638-02	-.84307-01	-.14817+00	-.19012+00	-.213[illegible]+00	-.22175+00
19/2 V	.17698+01	.18489+01	.19221+01	.19894+01	.20327+01	.20377+01	.20038+01	.19321+01	.18256+01	.17048+01
37/1 V	.22813+00	.32554+00	.41618+00	.48448+00	.54156+00	.59362+00	.64562+00	.69669+00	.74360+00	.78612+00

1/0 P	.48386+00	.48892+00	.494[illegible]+00	.49924+00	.50[illegible]+00	.505[illegible]3+00	.50734+00	.50947+00	.512[illegible]+00	.5[illegible]448+00
10/0 P	.68076+00	.63793+00	.740[illegible]1+00	.65775+00	.61573+00	.59418+00	.58675+00	.59154+00	.607[illegible]+00	.63200+00
19/0 P	.20016+00	.27914+00	.346[illegible]+00	.39792+00	.43531+00	.46672+00	.49712+00	.52543+00	.548[illegible]+00	.56591+00

	51	52	53	54	55	56	57	58	59	60
T	.15000+01	.15500+01	.16000+01	.16500+01	.17000+01	.17500+01	.18000+01	.18500+01	.19000+01	.19500+01
19/1 D	.22376+00	.21278+00	.2018[illegible]+00	.19080+00	.17039+00	.167[illegible]+00	.15552+00	.14334+00	.13111+00	.11881+00
19/2 D	.15720+01	.16510+01	.172[illegible]+01	.18062+01	.18844+01	.196[illegible]3+01	.20383+01	.21121+01	.218[illegible]+01	.22578+01
1/1 V	-.21114+01	-.21224+01	-.21311+01	-.21356+01	-.21[illegible]38+01	-.212[illegible]8+01	-.20998+01	-.20640+01	-.201[illegible]+01	-.19699+01
19/1 V	-.22115+00	-.21807+00	-.218[illegible]+00	-.22410+00	-.23[illegible]53+00	-.23948+00	-.24297+00	-.24419+00	-.245[illegible]+00	-.24663+00
19/2 V	.16057+01	.15536+01	.154[illegible]3+01	.15609+01	.15[illegible]80+01	.154[illegible]3+01	.14965+01	.14549+01	.145[illegible]+01	.14712+01
37/1 V	.82749+00	.87000+00	.912[illegible]8+00	.95361+00	.99[illegible]10+00	.103[illegible]8+01	.10831+01	.11324+01	.118[illegible]+01	.12481+01
1/0 P	.51666+00	.51997+00	.52615+00	.53687+00	.55[illegible]15+00	.580[illegible]5+00	.61700+00	.66398+00	.717[illegible]+00	.76875+00
10/0 P	.65932+00	.68427+00	.702[illegible]+00	.71160+00	.71655+00	.72145+00	.72819+00	.73546+00	.74111+00	.74441+00
19/0 P	.58043+00	.59456+00	.60719+00	.61607+00	.62213+00	.626[illegible]+00	.63066+00	.63078+00	.625[illegible]+00	.60947+00

	61	62	63	64	65	66	67	68	69	70
T	.20000+01	.21000+01	.22000+01	.23000+01	.24000+01	.25000+01	.26000+01	.27000+01	.28000+01	.29000+01
19/1 D	.10647+00	.82492-01	.60820-01	.42618-01	.28208-01	.17198-01	.80888-02	-.78444-03	-.955[illegible]-02	-.17431-01
19/2 D	.23116+01	.24797+01	.26323+01	.27985+01	.29804+01	.31719+01	.33655+01	.35543+01	.373[illegible]+01	.39234+01
1/1 V	-.19267+01	-.18709+01	-.185[illegible]0+01	-.18488+01	-.18218+01	-.18168+01	-.18301+01	-.18305+01	-.182[illegible]+01	-.18313+01
19/1 V	-.24700+00	-.23265+00	-.200[illegible]+00	-.16327+00	-.12493+00	-.952[illegible]6-01	-.86920-01	-.90545-01	-.849[illegible]-01	-.72478-01
19/2 V	.14815+01	.14807+01	.157[illegible]+01	.17522+01	.18858+01	.19438+01	.19274+01	.18484+01	.182[illegible]+01	.18824+01
37/1 V	.13097+01	.13850+01	.14114+01	.14201+01	.14[illegible]52+01	.143[illegible]2+01	.14610+01	.15040+01	.155[illegible]+01	.16139+01
1/0 P	.81041+00	.85088+00	.86059+00	.86848+00	.88[illegible]90+00	.89330+00	.88663+00	.88208+00	.884[illegible]+00	.88087+00
10/0 P	.74[illegible]27+00	.75485+00	.778[illegible]+00	.81195+00	.84835+00	.876[illegible]1+00	.88625+00	.88301+00	.883[illegible]+00	.89160+00
19/0 P	.63[illegible]50+00	.71372+00	.74721+00	.76256+00	.77[illegible]47+00	.78606+00	.81236+00	.85450+00	.908[illegible]+00	.95972+00

	71	72	73	74	75	76	77	78	79	80
T	.30000+01	.31000+01	.32000+01	.33000+01	.34000+01	.35000+01	.36000+01	.37000+01	.38000+01	.39000+01
19/1 D	-.24[illegible]65-01	-.30727-01	-.361[illegible]-01	-.40069-01	-.42295-01	-.438[illegible]5-01	-.46221-01	-.49653-01	-.533[illegible]-01	-.56859-01
19/2 D	.41108+01	.42912+01	.445[illegible]+01	.46209+01	.47778+01	.49325+01	.50898+01	.52535+01	.542[illegible]0+01	.55899+01
1/1 V	-.18430+01	-.18360+01	-.182[illegible]3+01	-.18283+01	-.18205+01	-.18005+01	-.17793+01	-.17500+01	-.171[illegible]+01	-.17016+01
19/1 V	-.66704-01	-.61029-01	-.4810[illegible]-01	-.29604-01	-.14920-01	-.16472-01	-.30645-01	-.38011-01	-.360[illegible]1-01	-.33956-01
19/2 V	.18663+01	.17411+01	.16341+01	.15859+01	.15505+01	.15419+01	.16004+01	.16738+01	.169[illegible]1+01	.16644+01
37/1 V	.16135+01	.16406+01	.162[illegible]3+01	.16244+01	.16[illegible]84+01	.164[illegible]8+01	.16430+01	.16303+01	.1631[illegible]+01	.16447+01
1/0 P	.87501+00	.87853+00	.887[illegible]+00	.89394+00	.90413+00	.92215+00	.94519+00	.97410+00	.100[illegible]+01	.10175+01
10/0 P	.90115+00	.91015+00	.92282+00	.94051+00	.95644+00	.959[illegible]2+00	.95036+00	.94270+00	.943[illegible]7+00	.94993+00
19/0 P	.98819+00	.98506+00	.964[illegible]+00	.95099+00	.95387+00	.96102+00	.95605+00	.94192+00	.934[illegible]+00	.93929+00

	81	82	83	84	85	86	87	88	89	90
T	.40000+01	.41000+01	.42000+01	.43000+01	.44000+01	.45000+01	.46000+01	.47000+01	.48000+01	.49000+01
19/1 D	-.59[illegible]86-01	-.62463-01	-.6447[illegible]-01	-.66368-01	-.67994-01	-.695[illegible]9-01	-.71973-01	-.75372-01	-.786[illegible]-01	-.80765-01
19/2 D	.57570+01	.59298+01	.61120+01	.62982+01	.64818+01	.66614+01	.68367+01	.70090+01	.718[illegible]+01	.73517+01
1/1 V	-.17133+01	-.17285+01	-.173[illegible]+01	-.17463+01	-.17390+01	-.17303+01	-.17403+01	-.17564+01	-.175[illegible]6+01	-.17468+01
19/1 V	-.28578-01	-.20967-01	-.1934[illegible]-01	-.18449-01	-.14069-01	-.17414-01	-.30684-01	-.37292-01	-.278[illegible]0-01	-.14793-01
19/2 V	.16764+01	.17793+01	.1866[illegible]+01	.18570+01	.18151+01	.17764+01	.17300+01	.17160+01	.172[illegible]4+01	.16940+01
37/1 V	.16511+01	.16480+01	.165[illegible]+01	.16776+01	.16945+01	.17031+01	.17241+01	.17502+01	.175[illegible]+01	.17482+01
1/0 P	.10[illegible]84+01	.98897+00	.971[illegible]3+00	.96328+00	.96787+00	.97525+00	.97058+00	.95792+00	.953[illegible]+00	.95954+00
10/0 P	.95[illegible]60+00	.96925+00	.974[illegible]2+00	.97760+00	.98086+00	.97909+00	.97014+00	.96371+00	.96911+00	.98108+00
19/0 P	.94457+00	.94341+00	.94601+00	.95977+00	.97437+00	.98434+00	.99828+00	.10151+01	.10212+01	.10114+01

	91
T	.50000+01
19/1 D	-.82043-01
19/2 D	.75198+01
1/1 V	-.17403+01
19/1 V	-.10764-01

19/2	V	.16678+01
37/1	V	.17345+01
1/0	P	.96885+00
10/0	P	.98829+00
19/0	P	.99335+00

APPENDIX D

USER INFORMATION FOR THE POSTPROCESSOR POSTPR

This appendix includes a copy of the users manual, and a sample input deck and subsequent output for the infinte cylindrical shell problem presented in Section 4.

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    THIS FUNCTIONAL COMPONENT OF THE UNDERWATER SHOCK ANALYSIS CODE
    IS RESPONSIBLE FOR THE TABULATION AND PRINTER-PLOT GRAPHIC DISPLAY
    OF SELECTED TRANSIENT RESPONSES AND PSEUDO-VELOCITY SHOCK SPECTRA
    UPON COMPLETION OF AN UNDERWATER SHOCK ANALYSIS OF A SUBMERGED
    STRUCTURE. IT CAN ALSO CREATE A PERMANENT FILE CONTAINING A SERIES
    OF SNAPSHOTS OF THE DEFORMED STRUCTURE AT USER SPECIFIED TIMES

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    THIS PROGRAM WAS DEVELOPED AND CODED BY JOHN A. DERUNTZ, JR.
    OF LOCKHEED MISSILES AND SPACE CO. RESEARCH LABS IN PALO ALTO
    CALIFORNIA. PLEASE CONSULT WITH AUTHOR BEFORE MAKING CHANGES
    AND ALSO REPORT ANY MALFUNCTIONS OR PROBLEMS. WRITE IN CARE OF
    LOCKHEED PALO ALTO RESEARCH LABORATORY, BLDG. 205, DEPT 52-33,
    3251 HANOVER ST., PALO ALTO, CALIF., 94304 OR CALL 415-493-4411
    EXTS. 45069 OR 45103.                               SEPTEMBER, 1980

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  W A R N I N G   F R O M   T H E   P R O G R A M M E R   G E N E R A L

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    THIS CODE CONTAINS THE SPECIAL INGREDIENT DMGASP NOT FOUND IN
    OTHER BRANDS. DMGASP IS A DATA MANAGEMENT UTILITY MODULE THAT
    WILL ACTIVATE AND DEACTIVATE ALL AUXILIARY STORAGE DATA FILES
    REFERENCED BY THE CODE. HENCE THE NAMES OF SUCH FILES SHOULD NOT
    APPEAR ON ANY CONTROL CARDS IN THE RUN STREAM WHICH MIGHT NORMALLY
    ACTIVATE AND DEACTIVATE SUCH FILES. THE USER IS ALSO CAUTIONED THAT
    PREVIOUSLY CREATED FILES MUST ALREADY BE RESIDENT IN THE SYSTEM
    BEFORE THE RUN IS INITIATED. IF A FILE HAS BEEN ROLLED-OUT TO TAPE
    DMGASP WILL ATTEMPT TO HAVE THE FILE ROLLED-IN EVERY 15 SECONDS
    FOR UP TO 6 MINUTES ON THE UNIVAC 1100-EXEC 8 OPERATING SYSTEM.
    IF AN EXISTING DATA FILE HAS NOT BEEN REFERENCED FOR SOME TIME IT
    IS THEREFORE GOOD POLICY TO SIMPLY ACTIVATE AND DEACTIVATE THE
    FILE BEFORE EXECUTION OF THIS CODE. IF THE USER ATTEMPTS TO CREATE
    A NEW DATA FILE WITH A NAME WHICH IS ALREADY ASSIGNED TO AN
    EXISTING FILE, THE UNIVAC VERSION OF DMGASP WILL MODIFY THE NAME
    OF THE FILE GENERATED BY THIS RUN TO AVOID ANY CONFLICT. FILE NAME
    DUPLICATION WILL CAUSE NO PROBLEM ON THE CDC SCOPE OPERATING
    SYSTEM AS SCOPE WILL SIMPLY CATALOG A NEW CYCLE OF THE SAME FILE.
    ON THE OTHER HAND THE CDC NOS SYSTEM IS SIMILAR TO UNIVAC IN THIS
    REGARD AND THE RUN WILL ABORT SINCE THE NAME-CHANGING FEATURE OF
    DMGASP HAS NOT BEEN IMPLEMENTED FOR NOS. QUALIFIER*FILENAME IS THE
    REQUIRED INPUT DATA FORMAT FOR ALL UNIVAC PERMANENT FILE NAMES.
    ON CDC SCOPE, THE QUALIFIER IS INTERPRETED AS THE USERS ID, WHICH
    IN MOST INSTALLATIONS CAN BE SELECTED ALMOST ARBITRARILY. ON CDC
    NOS, THE QUALIFIER IS INTERPRETED AS THE USERS CATALOG NUMBER,
    WHICH IS USUALLY PRESCRIBED BY THE INSTALLATION. A CYCLE NUMBER
    CAN ALSO BE APPENDED TO GIVE THE FORM QUALIFIER*FILENAME(CYCLE)
    ON CDC SCOPE
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                     P R O G R A M     S I Z E

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   ALL ARRAYS REFERRENCED IN THIS CODE THAT ARE PROBLEM DEPENDENT
   RESIDE IN BLANK COMMON. THE SIZE OF BLANK COMMON IS DETERMINED BY
   A PARAMETER STATEMENT IN THE MAIN PROGRAM FOR THE UNIVAC 1100-OS
   VERSION, HENCE A RECOMPILATION IS NECESSARY TO INCREASE OR
   DECREASE CORE ALLOCATION. IN THE CDC 6600 VERSION RECOMPILATION IS
   UNNECESSARY AS THE LENGTH OF BLANK COMMON IS SET BY A FIELD LENGTH
   REQUEST IN THE CONTROL CARD DECK

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   D E F I N I T I O N    O F    I N P U T    P A R A M E T E R S

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   INPUT VARIABLE NAMES GIVEN BELOW ARE GENERALLY THOSE WHICH ARE
   ALSO USED IN THE CODING AND THE VARIABLE TYPES CORRESPOND TO
   STANDARD FORTRAN USAGE:

                 A   -   ALPHANUMERIC
                 E   -   FLOATING POINT
                 F   -   FIXED POINT
                 I   -   INTEGER
                 L   -   LOGICAL

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   VARIABLE      TYPE.                   DESCRIPTION
   --------      ----                    -----------

   NFILES         I      NUMBER OF RESPONSE FILES THAT MAKE UP THE
                         DESIRED TRANSIENT ANALYSIS DISPLAY. NFILES
                         PRESENTLY CANNOT EXCEED TEN (10)

   NTIMES         I      THE NUMBER OF RESPONSE RECORDS THAT ARE
                         STORED IN ANY PARTICULAR RESPONSE FILE.
                         THESE MUST BE ORDERED CHRONOLOGICALLY FOR
                         INPUT. NTIMES WILL GENERALLY BE THE NUMBER
                         OF TIME STEPS MADE DURING THE TIME THE
                         FILE WAS CREATED EXCEPT IF THE FILE GOES
                         BACK TO TIME EQUAL TO ZERO. IN THIS CASE
                         NTIMES IS EQUAL TO THE NUMBER OF TIME
                         STEPS PLUS ONE TO ACCOUNT FOR THE FIRST
                         RECORD THAT CONTAINS THE INITIAL
                         CONDITIONS

   PRENAM         A      NAME OF PRE-PROCESSED MASS STORAGE FILE
                         CONTAINING ALL FLUID AND STRUCTURE DATA

   XVPNAM         A      NAMES OF RESPONSE FILES THAT MAKE UP A
                         CONTINUOUS SET OF TRANSIENT DATA, ORDERED
                         CHRONOLOGICALLY

   FORWRT         L      TRUE IF PERMANENT FILES DENOTED BY XVPNAM
```

		WERE CREATED USING UNFORMATTED FORTRAN WRITE. OTHERWISE FILES WERE CREATED BY DIRECT TRANSFER USING THE DATA MANAGEMENT SYSTEM DMGASP
DISPLA	L	TRUE IF SELECTED TRANSIENT RESPONSE HISTORIES ARE TO BE DISPLAYED. OTHERWISE FALSE. THIS VARIABLE MUST BE TRUE EVEN IF PSEUDO-VELOCITY SHOCK SPECTRA ARE THE ONLY ONLY OUTPUT DESIRED SINCE STRUCTURAL VELOCITY HISTORIES MUST BE USED FOR THIS COMPUTATION
DEFORM	L	TRUE IF A PERMANENT FILE IS TO BE CREATED THAT CONTAINS A CHRONOLOGICAL SUCCESSION OF RECORDS EACH OF WHICH CONSISTS OF THE COMPLETE DISPLACEMENT FIELD AT SPECIFIC TIMES WITHOUT ANY EXTRANEOUS TIME OR BOOKKEEPING DATA. SUCH A FILE CAN BE IMAGINED AS A SERIES OF SNAPSHOTS OF THE DEFORMED STRUCTURE THROUGHOUT THE SHOCK ANALYSIS. THIS CAPABILITY CANNOT BE USED IF FORWRT IS TRUE
LISTRE	L	TRUE IF TRANSIENT RESPONSE HISTORIES ARE TO BE LISTED IN TABULAR FORM. OTHERWISE FALSE
PRTPLT	L	TRUE IF PRINTER PLOTS ARE TO BE GENERATED FOR TRANSIENT RESPONSE HISTORIES. OTHERWISE FALSE
VECPLT	L	TRUE IF PLOTS ARE TO BE GENERATED FOR TRANSIENT RESPONSE HISTORIES. OTHERWISE FALSE. A PLOT PACKAGE IS NOT PROVIDED WITH THE USA CODE AND IT IS THE USERS RESPONSIBILITY TO COMPLETE THIS FEATURE IN A CALL FROM SUBROUTINE RESSHK IF DESIRED. THE EXISTING CALL USES 'DISPLA' SOFTWARE
NWETHS	I	NUMBER OF STRUCTURAL HISTORIES (EITHER DISPLACEMENTS OR VELOCITIES) TO BE DISPLAYED FOR WHICH THE APPROPRIATE STRUCTURAL FREEDOMS CAN BE IDENTIFIED INTERNALLY THROUGH THE FREEDOM/EQUATION CORRESPONDENCE TABLE. ALL STRUCTURAL NODES WHICH PARTICIPATE IN THE FLUID-STRUCTURE TRANSFORMATION WILL FALL INTO THIS CATEGORY AS WELL AS ANY OTHERS WHOSE GRID POINT COORDIATES WERE ENTERED AS DATA FOR THE FLUID MASS PROCESSOR
NDRYHS	I	NUMBER OF STRUCTURAL HISTORIES (EITHER DISPLACEMENTS OR VELOCITIES) TO BE DISPLAYED FOR WHICH THE APPROPRIATE STRUCTURAL FREEDOMS CANNOT BE IDENTIFIED INTERNALLY THROUGH THE FREEDOM/EQUATION CORRESPONDENCE TABLE. DRY STRUCTURE NODE

		POINTS CAN FALL INTO THIS CATEGORY IF THE USER DID NOT INCLUDE THEM IN THE DATA STREAM FOR THE FLUID MASS PROCESSOR. IN THIS CASE ONE MUST IDENTIFY THE INTERNAL SEQUENCE NUMBER APPROPRIATE TO THE DESIRED DEGREE OF FREEDOM BY A MYSTICAL PROCESS WHICH INVOLVES THE INTIMATE KNOWLEDGE OF THE ELIMINATION ORDER AND ANY REDUCTION OF THE NUMBER OF ACTIVE FREEDOMS DUE TO THE APPLICATION OF CONSTRAINTS. MORAL OF THE STORY - RUN ALL STRUCTURAL GRID POINTS THROUGH THE FLUID MASS PROCESSOR EVEN IF THEY NEVER GET WET
NUMSET	I	NUMBER OF DATA SETS USED TO DEFINE RESPONSE DISPLAYS FOR SEVERAL DEGREES OF FREEDOM THAT DIFFER BY A CONSTANT INCREMENT. THIS FEATURE CAN BE USED TO SIMPLIFY INPUT DATA TO SHOW A NUMBER OF TRANSIENT RESULTS AT DIFFERENT PLACES ALONG A GENERATOR OF A CYLINDER OR. AROUND THE CIRCUMFERENCE AT ANY AXIAL STATION
NODOUT	I	EXTERNAL INDENTIFICATION NUMBER OF STRUCTURAL NODE FOR WHICH A TIME HISTORY DISPLAY IS DESIRED
NFROUT	I	STRUCTURAL DEGREE OF FREEDOM NUMBER FOR WHICH A TIME HISTORY DISPLAY IS DESIRED
NEQHST	I	INTERNAL SEQUENCE NUMBER DETERMINED BY HAND FOR STRUCTURAL DEGREES OF FREEDOM WHICH ARE TO BE DISPLAYED AND ARE NOT INCLUDED IN THE FREEDOM/EQUATION CORRESPONDENCE TABLE FOR REASONS KNOWN ONLY TO THE USER
NODFIR	I	FIRST OF SEVERAL EQUALLY INCREMENTED NODE NUMBERS AT WHICH OUTPUT IS DESIRED
NODLAS	I	LAST OF SEVERAL EQUALLY INCREMENTED NODE NUMBERS AT WHICH OUTPUT IS DESIRED
NODINC	I	INCREMENT TO BE APPLIED IN ASSIGNING NODE NUMBERS FOR OUTPUT
NPREHS	I	NUMBER OF FLUID PRESSURE HISTORIES TO BE DISPLAYED
NEQHPR	I	FLUID CONTROL POINT NUMBER FOR WHICH A TIME HISTORY DISPLAY IS DESIRED FOR THE TOTAL PRESSURE
SCALEF	L	TRUE IF MULTIPLICATIVE CONSTANT FACTORS ARE TO BE APPLIED TO THE DISPLAYED VALUES OF THE STRUCTURAL DISPLACEMENTS AND VELOCITIES. TOTAL FLUID PRESSURES AND/OR TIME. OTHERWISE FALSE. SUCH FACTORS ARE

		NOT APPLIED TO THE PERMANENT FILES CONTAINING THE RESPONSE HISTORIES
RESFAC	E,F	MULTIPLICATIVE LENGTH CONVERSION FACTOR TO BE APPLIED TO THE DISPLAYED VALUES OF THE STRUCTURAL DISPLACEMENT AND VELOCITY HISTORIES
PREFAC	E,F	MULTIPLICATIVE PRESSURE CONVERSION FACTOR TO BE APPLIED TO THE DISPLAYED VALUES OF THE TOTAL PRESSURE HISTORIES
TIMFAC	E,F	MULTIPLICATIVE TIME CONVERSION FACTOR TO BE APPLIED TO THE DISPLAYED VALUES OF THE TIME AXIS FOR ALL THE TRANSIENT RESPONSE HISTORIES
SHSPEC	L	TRUE IF PSEUDO-VELOCITY SHOCK SPECTRA ARE ALSO DESIRED FOR STRUCTURAL FREEDOMS WHOSE VELOCITY RESPONSE IS TO BE DISPLAYED, OTHERWISE FALSE
SHLIST	L	TRUE IF PSEUDO-VELOCITY SHOCK SPECTRA ARE TO BE LISTED IN TABULAR FORM, OTHERWISE FALSE
SHPRPL	L	TRUE IF PRINTER PLOTS ARE TO BE GENERATED FOR PSEUDO-VELOCITY SHOCK SPECTRA, OTHERWISE FALSE
SHVCPL	L	TRUE IF VECTOR PLOTS ARE TO BE GENERATED FOR PSEUDO-VELOCITY SHOCK SPECTRA, OTHERWISE FALSE (SEE VECPLT)
FREQLW	E,F	LOWER LIMIT OF FREQUENCY RANGE TO BE SCANNED FOR PSEUDO-VELOCITY SHOCK SPECTRA
FREQUP	E,F	UPPER LIMIT OF FREQUENCY RANGE TO BE SCANNED FOR PSEUDO-VELOCITY SHOCK SPECTRA
DFREQ	E,F	FREQUENCY INCREMENT TO BE USED IN GENERATING PSEUDO-VELOCITY SHOCK SPECTRA
SNPNAM	A	NAME OF PERMANENT FILE TO BE CREATED CONTAINING STRUCTURAL SNAPSHOT DATA
NSNAP	I	NUMBER OF TIMES FOR WHICH THE DISPLACEMENT FIELD IS TO BE WRITTEN ON THE PERMANENT FILE DENOTED BY SNPNAM
PRTDIS	L	TRUE IF STRUCTURAL DISPLACEMENT FIELD IS TO BE PRINTED FOR EACH SNAPSHOT, OTHERWISE FALSE
TIME	E,F	TIME AT WHICH SNAPSHOT IS DESIRED, MUST BE ORDERED CHRONOLOGICALLY

* *

```
                 I N P U T     D A T A     C A R D     D E C K

 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

       ALL INPUT DATA EXCEPT ALPHANUMERIC DATA MUST BE RIGHT JUSTIFIED
       IN EIGHT (8) COLUMN FIELDS WHICH CAN OCCUPY THE ENTIRE CARD.
       ALPHANUMERIC DATA MUST BE LEFT JUSTIFILD IN TWENTY (20) COLUMN
       FIELDS. FILE NAME PLUS QUALIFIER IS CURRENTLY RESTRICTED TO
       EIGHTEEN (18) CHARACTERS FOR UNIVAC OPERATION WHILE NINETEEN (19)
       CHARACTERS MAY BE USED FOR CDC OPERATION

       TASK DEFINITION (MAIN PROGRAM POSTPR):
       -------------------------------------

       72 COLUMN ALPHNUMERIC TITLE, ONLY THE FIRST 48 WILL APPEAR ON PLOTS
       NFILES
       NTIMES(I), I=1,NFILES
       PRENAM
       XVPNAM(I), I=1,NFILES
       FORWRT  DISPLA  DEFORM

       TRANSIENT RESPONSE DISPLAY (SUBROUTINE RESSHK):
       ----------------------------------------------

       IF DISPLA = .FALSE. SKIP ALL INPUT FROM HERE TO SUBROUTINE SNAPPY

       LISTRE  PRTPLT  VECPLT

       TRANSIENT RESPONSE DISPLAY (SUBROUTINE STRDSP):
       ----------------------------------------------

       NWETHS  NDRYHS  NUMSET                      )
       NODOUT  NFROUT          )                   )
          .       .            )   TOTAL = NWETHS  )
          .       .            )                   )
       NODOUT  NFROUT  NEQHST  )                   )   THIS SET FOR
          .       .       .    )   TOTAL = NDRYHS  )
          .       .       .    )                   )   DISPLACEMENTS
                                                   )
       IF NUMSET = 0 OMIT THE FOLLOWING CARD       )
                                                   )
       NFROUT  NODFIR  NODLAS  NODINC              )

       NWETHS  NDRYHS  NUMSET                      )
       NODOUT  NFROUT          )                   )
          .       .            )   TOTAL = NWETHS  )
          .       .            )                   )
       NODOUT  NFROUT  NEQHST  )                   )   THIS SET FOR
          .       .       .    )   TOTAL = NDRYHS  )
          .       .       .    )                   )   VELOCITIES
                                                   )
       IF NUMSET = 0 OMIT THE FOLLOWING CARD       )
                                                   )
       NFROUT  NODFIR  NODLAS  NODINC              )

       TRANSIENT RESPONSE DISPLAY (SUBROUTINE RESSHK):
       ----------------------------------------------
```

```
NPREHS  NUMSET
NEQHPR
   .                       )   TOTAL = NPREHS
   .                       )

IF NUMSET = 0 OMIT THE FOLLOWING CARD

NODFIR  NODLAS  NODINC

TRANSIENT RESPONSE DISPLAY (SUBROUTINE FILBUF):
-----------------------------------------------

SCALEF

IF SCALEF = .TRUE. READ THE FOLLOWING CARD

RESFAC  PREFAC  TIMFAC

PSEUDO-VELOCITY SHOCK SPECTRA (SUBROUTINE RESSHK):
--------------------------------------------------

SHSPEC

IF SHSPEC = .TRUE. READ THE FOLLOWING CARDS

SHLIST  SHPRPL  SHVCPL
FREQLW  FREQUP  DFREQ

SNAPSHOT FILE CREATION (SUBROUTINE SNAPPY):
-------------------------------------------

IF DEFORM = .FALSE. THIS TERMINATES THE INPUT DATA DECK

SNPNAM
NSNAP
PRTDIS
TIME          )
   .          )   TOTAL = NSNAP
   .          )
```

The following discussion is provided as an aid to user understanding of the sample output that is included here.

The input deck shown on the next page requests vector plots for both the transient response histories and pseudo-velocity shock spectra. This is appropriate if the DISSPLA plot package is available at the us installation. Otherwise appropriate modifications must either be made to use a different plot package or the input deck should be modified. In any case the printer plot package is resident in USA.

The format used for listing the pseudo-velocity shock spectra is similar to that used for the display of the transient response histories shown in Appendix C except that the first row is now frequency rather than time.

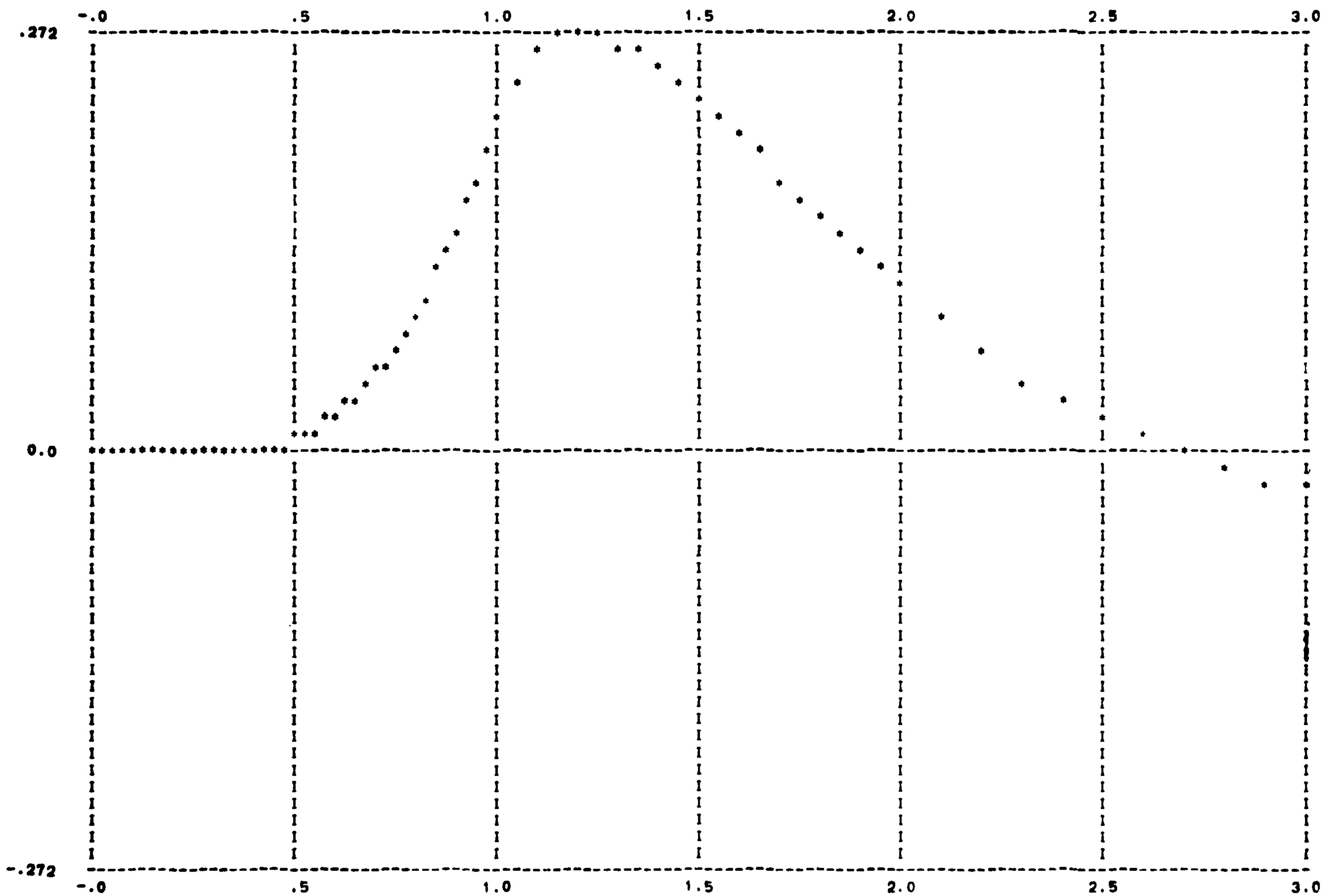
```
INFINITE CYLINDER, PLANE STEP WAVE
           1
          91
CYL*PREP
CYL*POST
           F         T         F
           F         T         T
           2         0
          19         1
          19         2
           4         0
           1         1
          19         1
          19         2
          37         1
           3
           1
          10
          19
           F
           T
           T         T         T
          0.        3.      .025
```

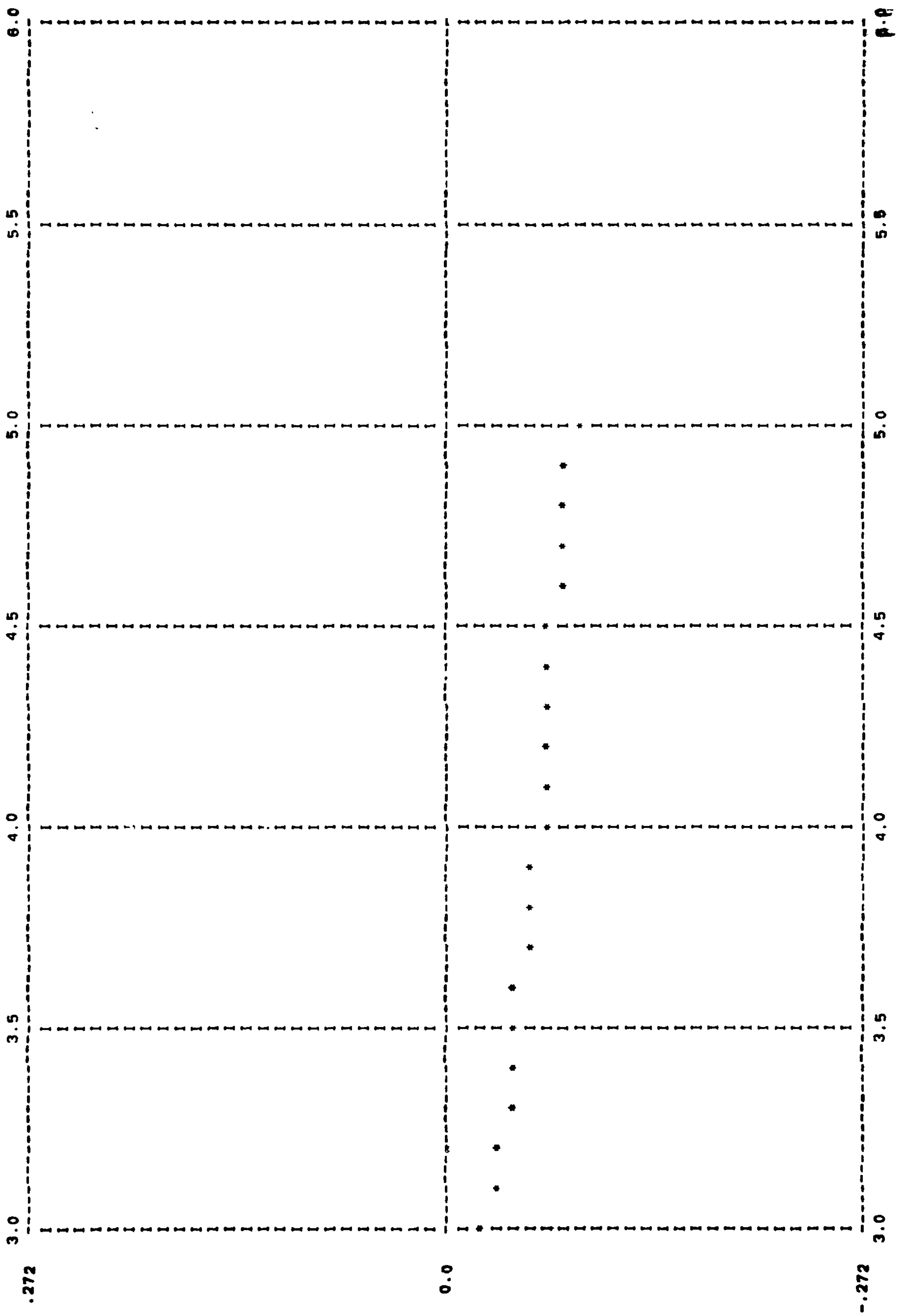
```
@XQT

@ADD,P CYLPOSDAT
```

INFINITE CYLINDER, PLANE STEP WAVE

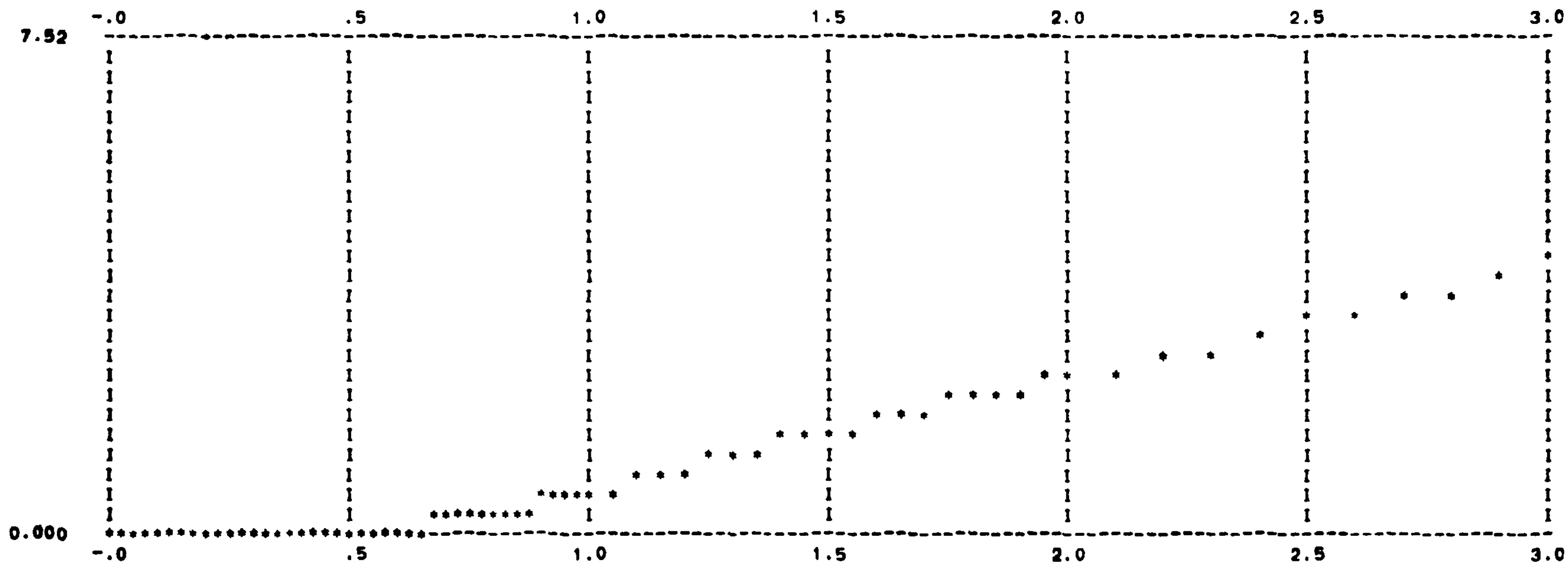
```
+++  ● ASG,AX       CYL*PREP.
+++  ● USE       16,CYL*PREP.

+++  ● FREE         CYL*PREP.

+++  ● ASG,AX       CYL*POST.
+++  ● USE       12,CYL*POST.

+++  ● FREE         CYL*POST.
```

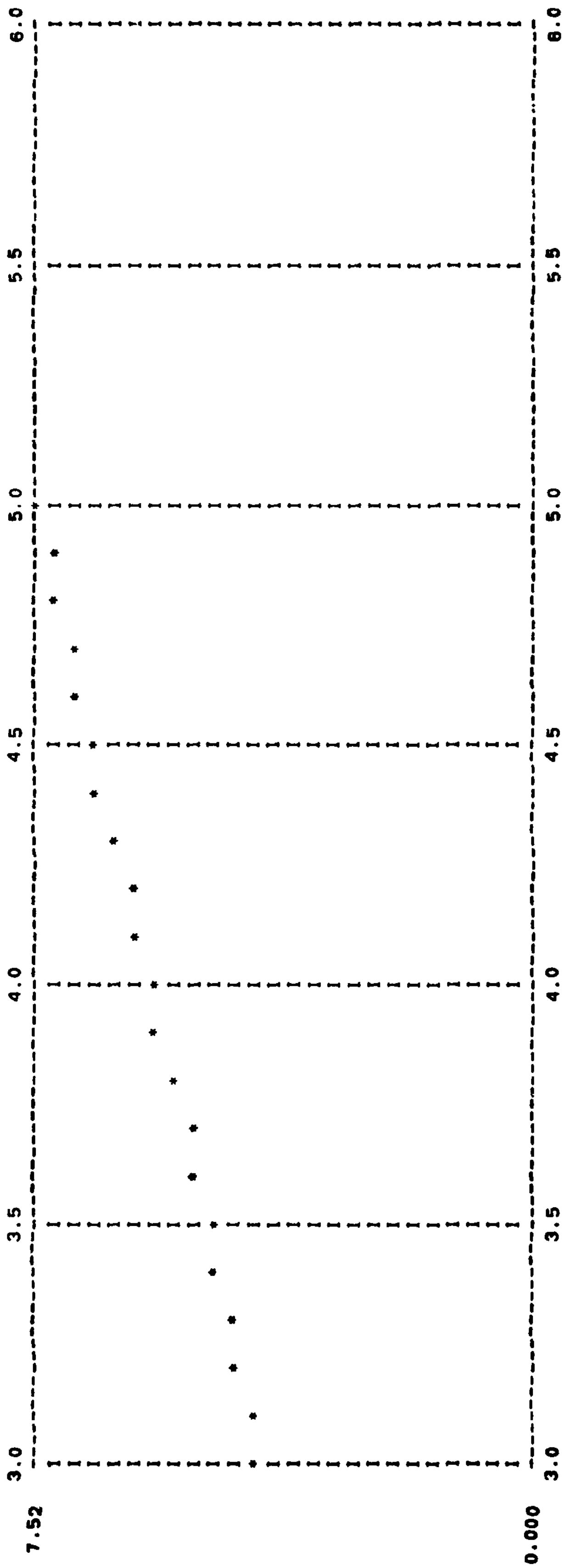
DISPLACEMENT RESPONSE OF STRUCTURAL NODE 19, FREEDOM NUMBER 1:



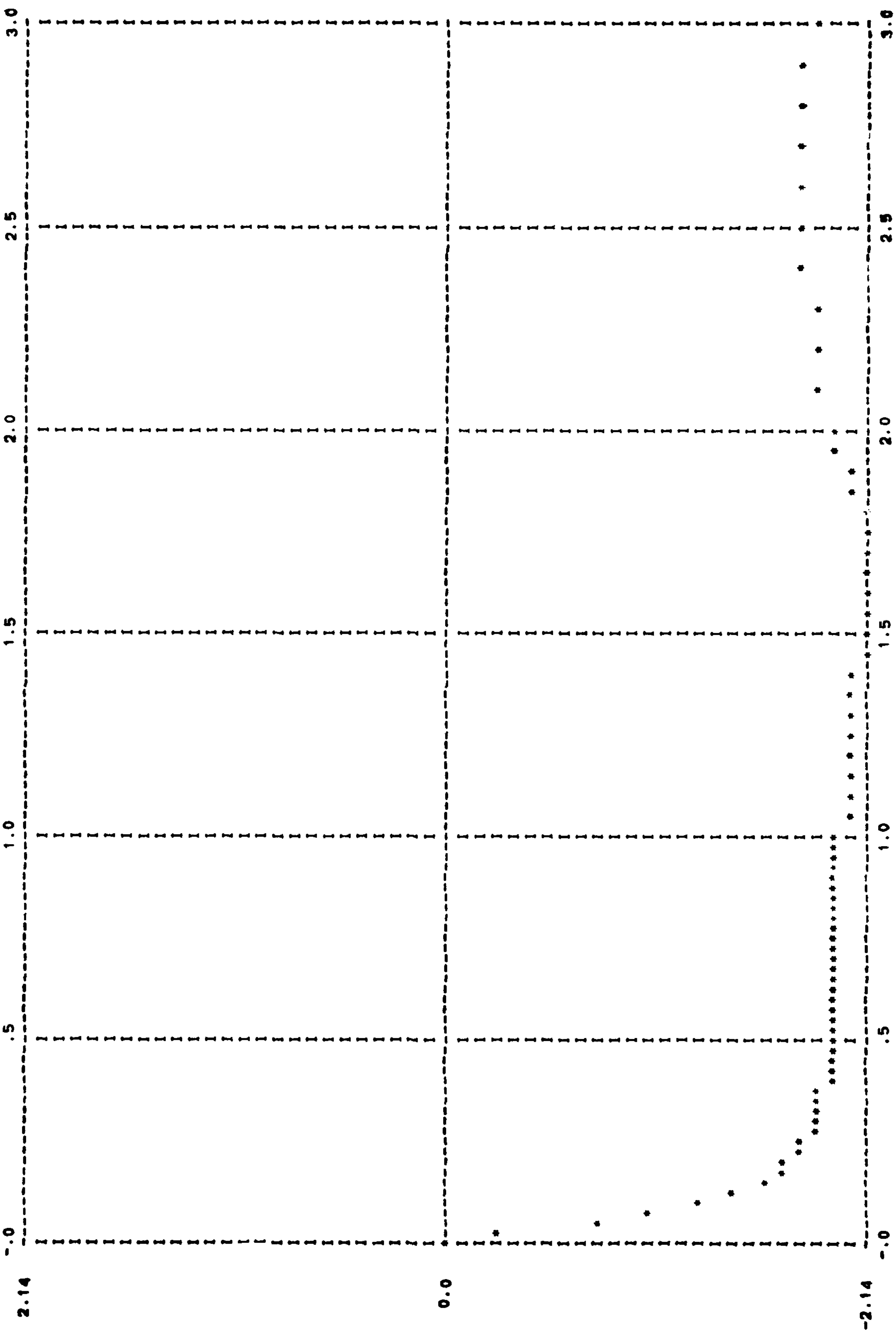

3.0
3.5
4.0
4.5
5.0
5.5
6.0
.272
0.0
-.272

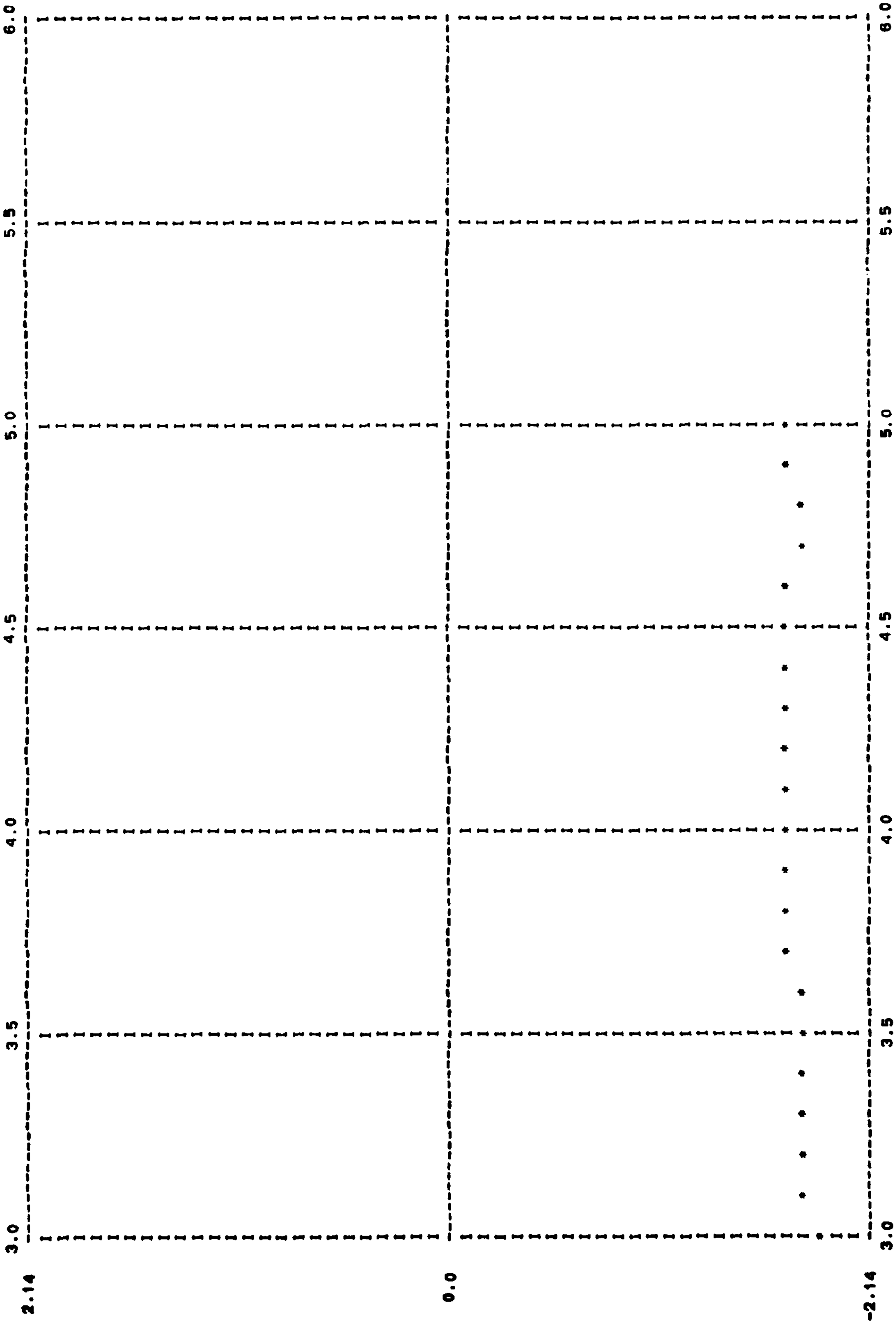
DISPLACEMENT RESPONSE OF STRUCTURAL NODE 19, FREEDOM NUMBER 2:

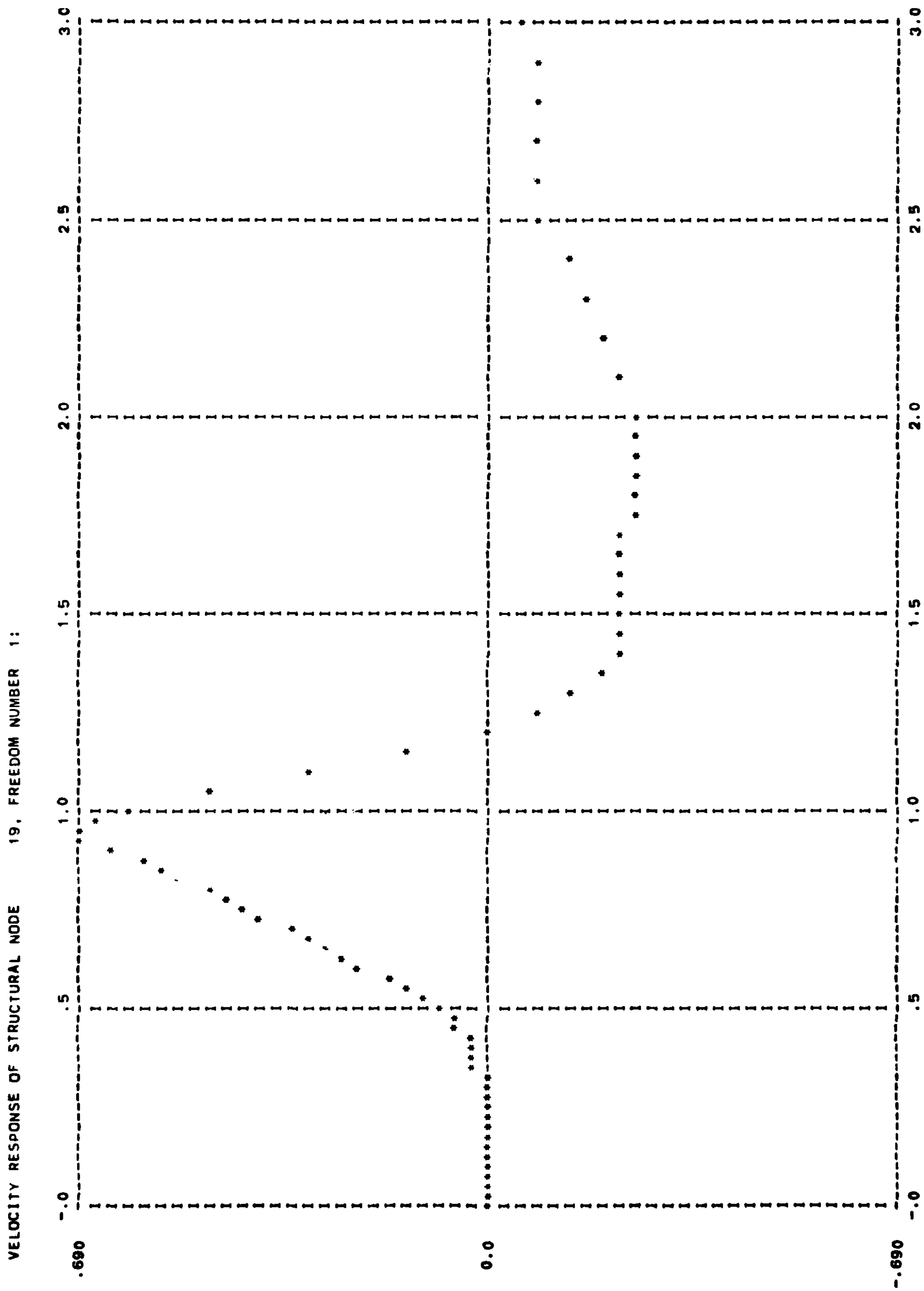


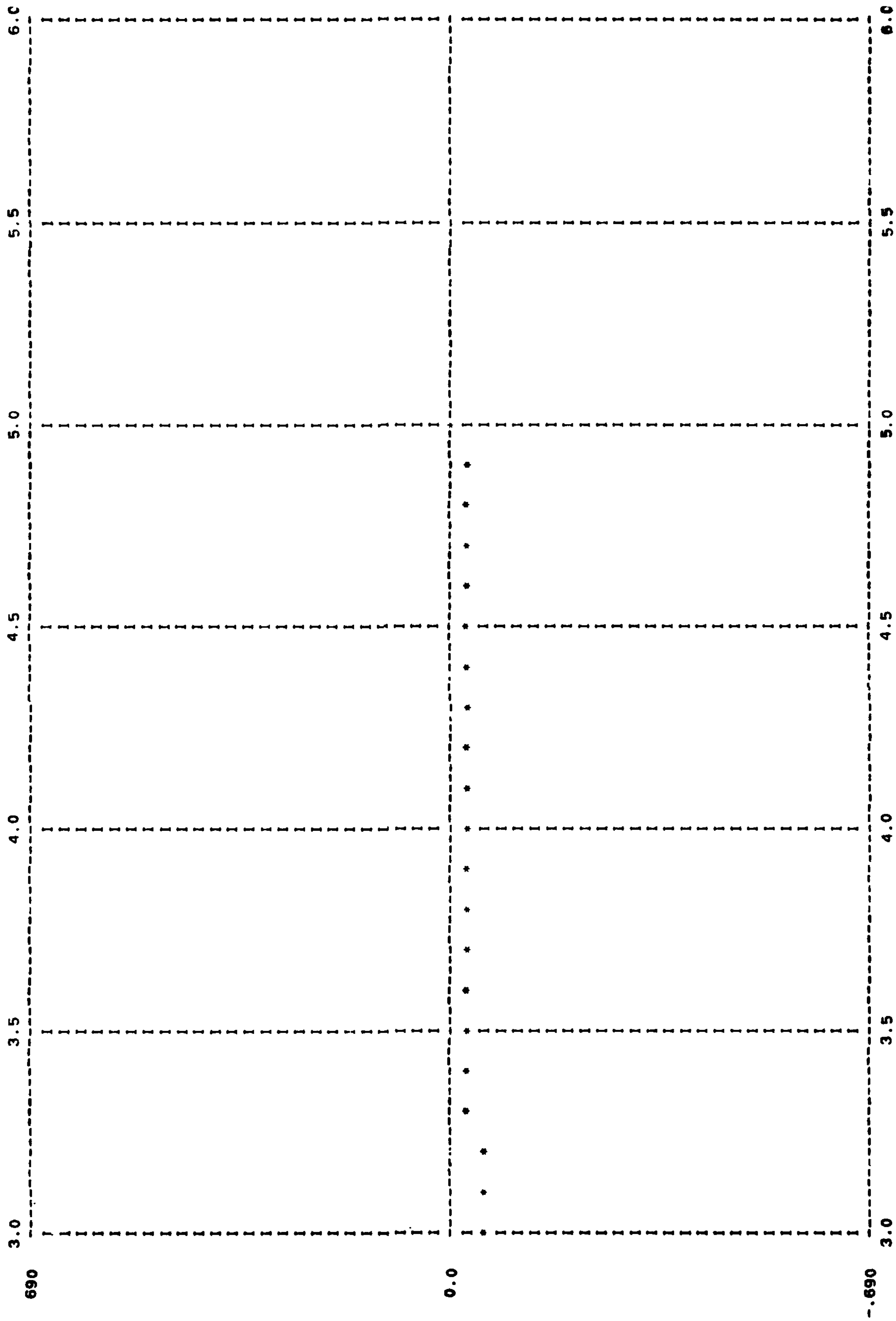

6.0
5.5
5.0
4.5
4.0
3.5
3.0
7.52
0.000

VELOCITY RESPONSE OF STRUCTURAL NODE 1, FREEDOM NUMBER 1:

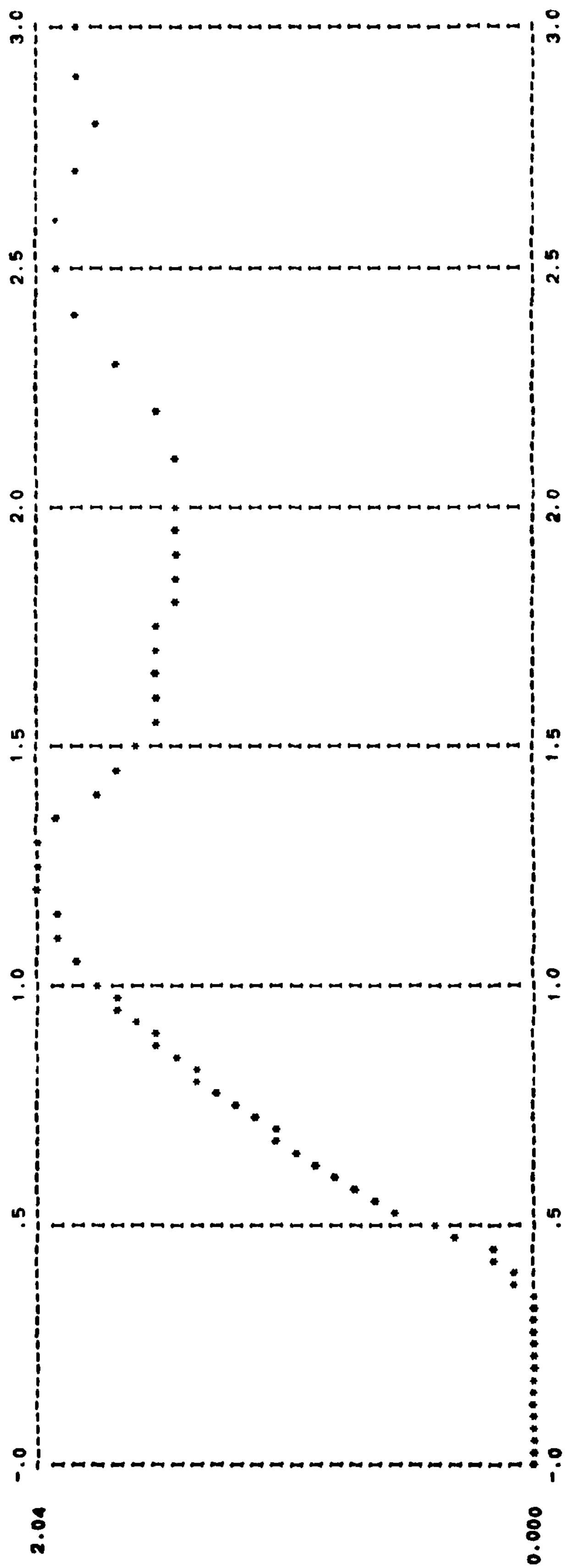


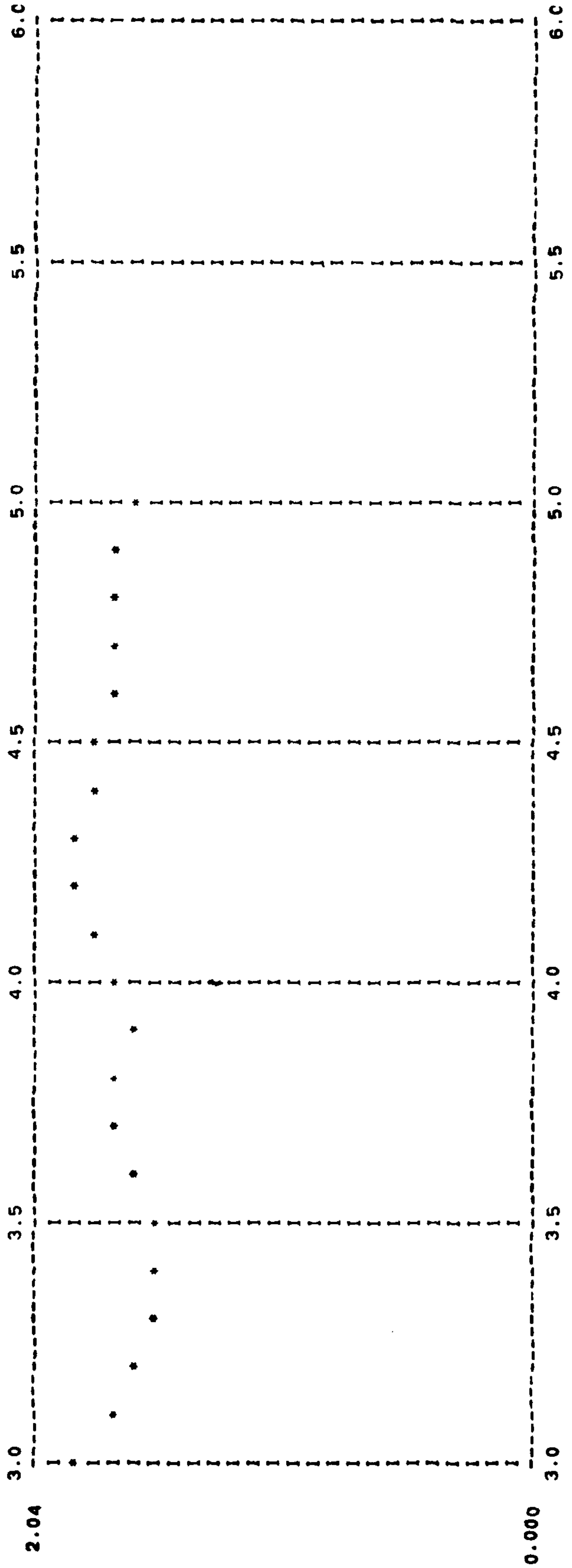

6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.14
0.0
-2.14


VELOCITY RESPONSE OF STRUCTURAL NODE 19, FREEDOM NUMBER 1:
-.0
.5
1.0
1.5
2.0
2.5
3.0
.690
0.0
-.690

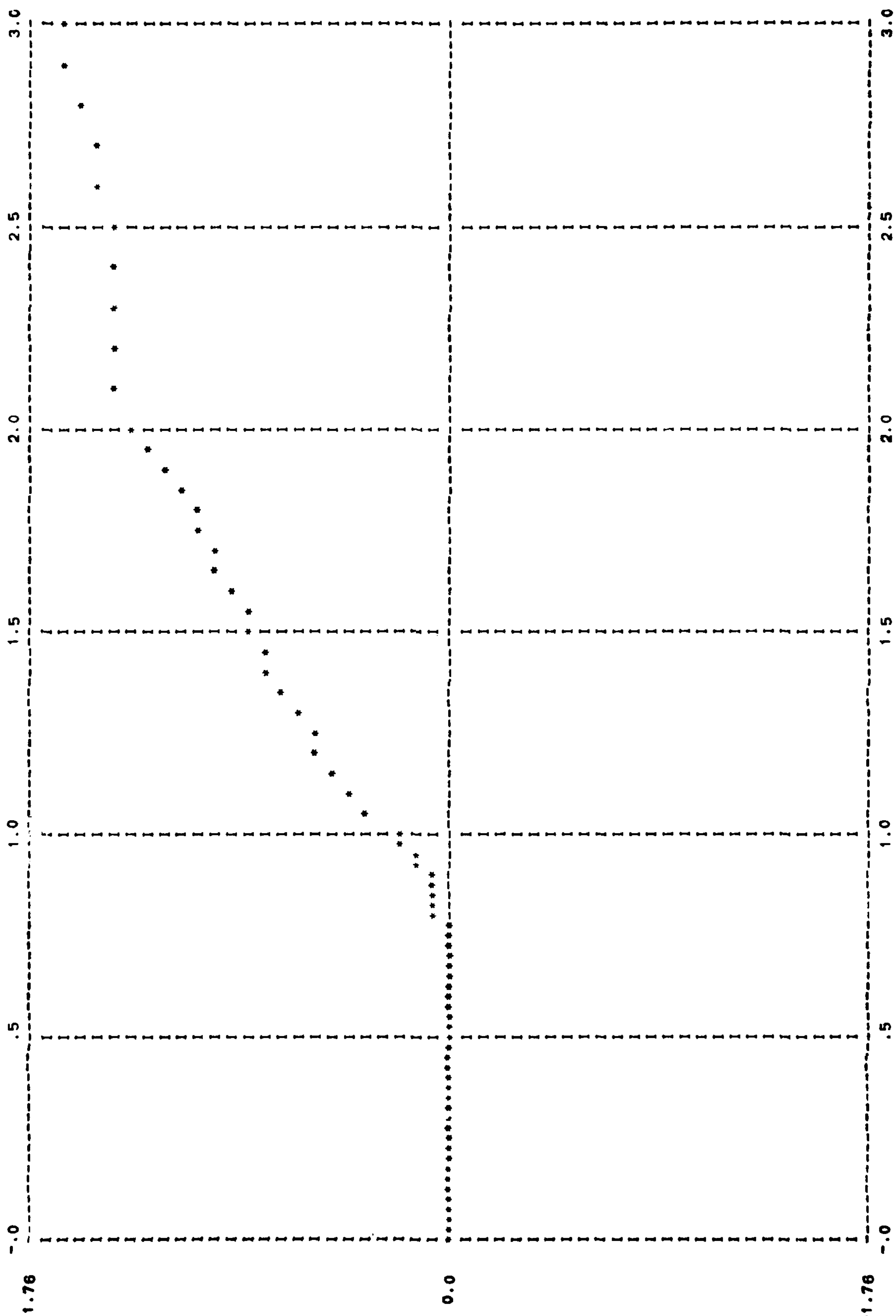

6.0
5.5
5.0
4.5
4.0
3.5
3.0
690
0.0
-.690

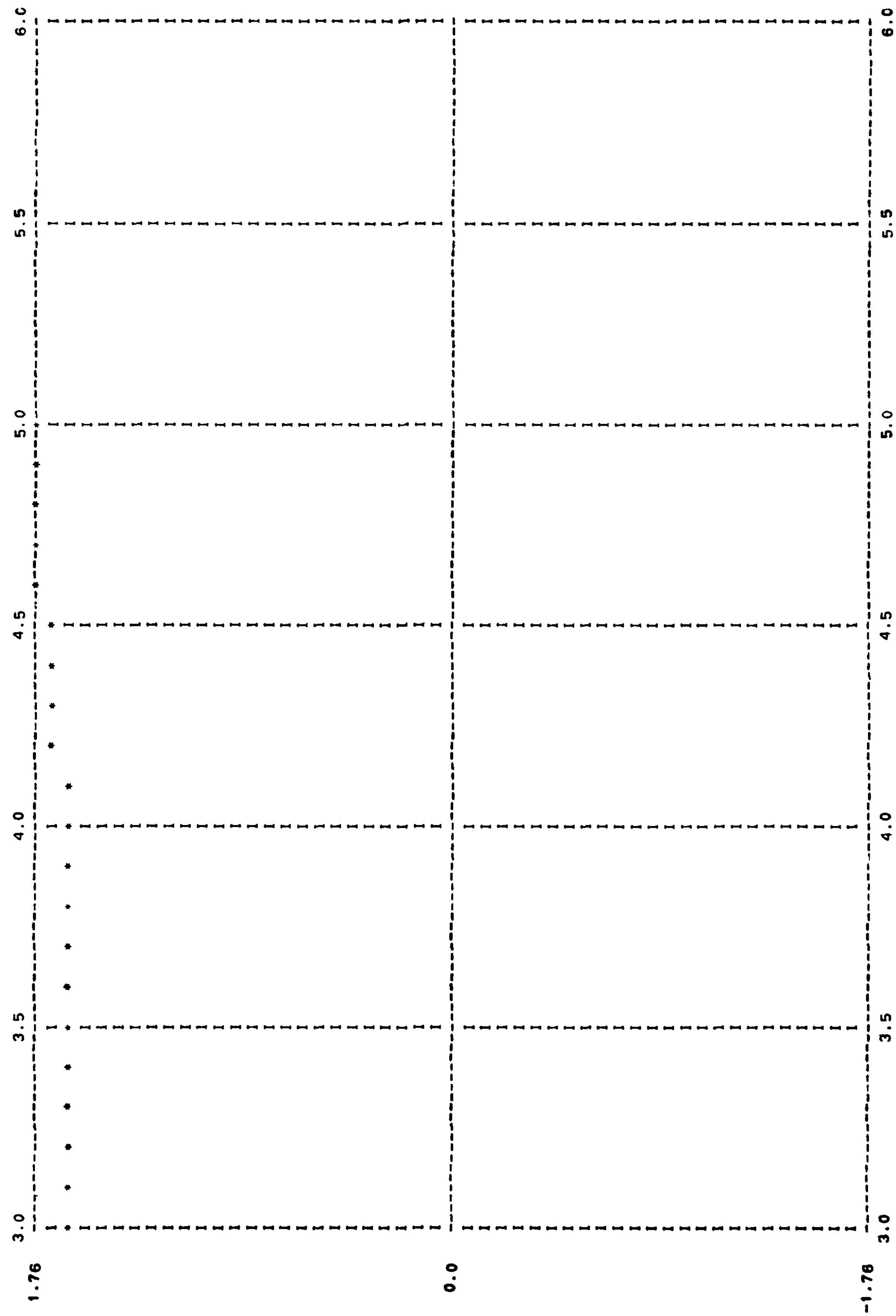
VELOCITY RESPONSE OF STRUCTURAL NODE 19, FREEDOM NUMBER 2:



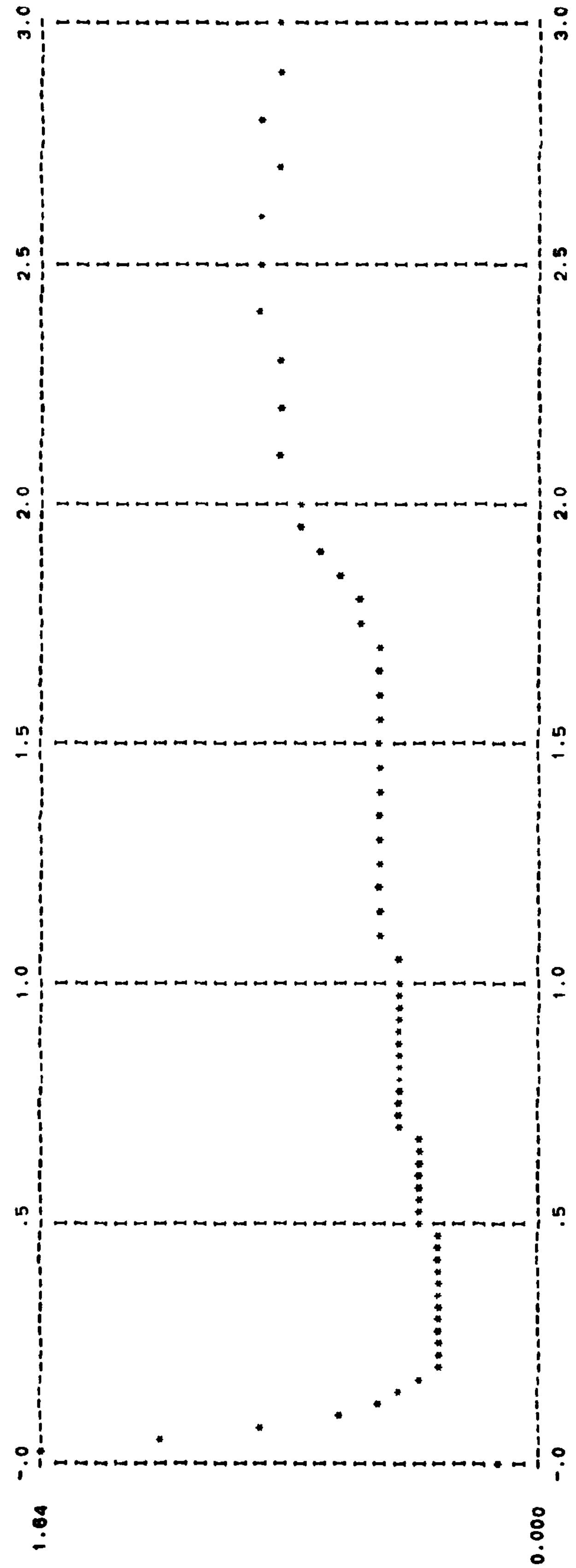

6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.04
0.000

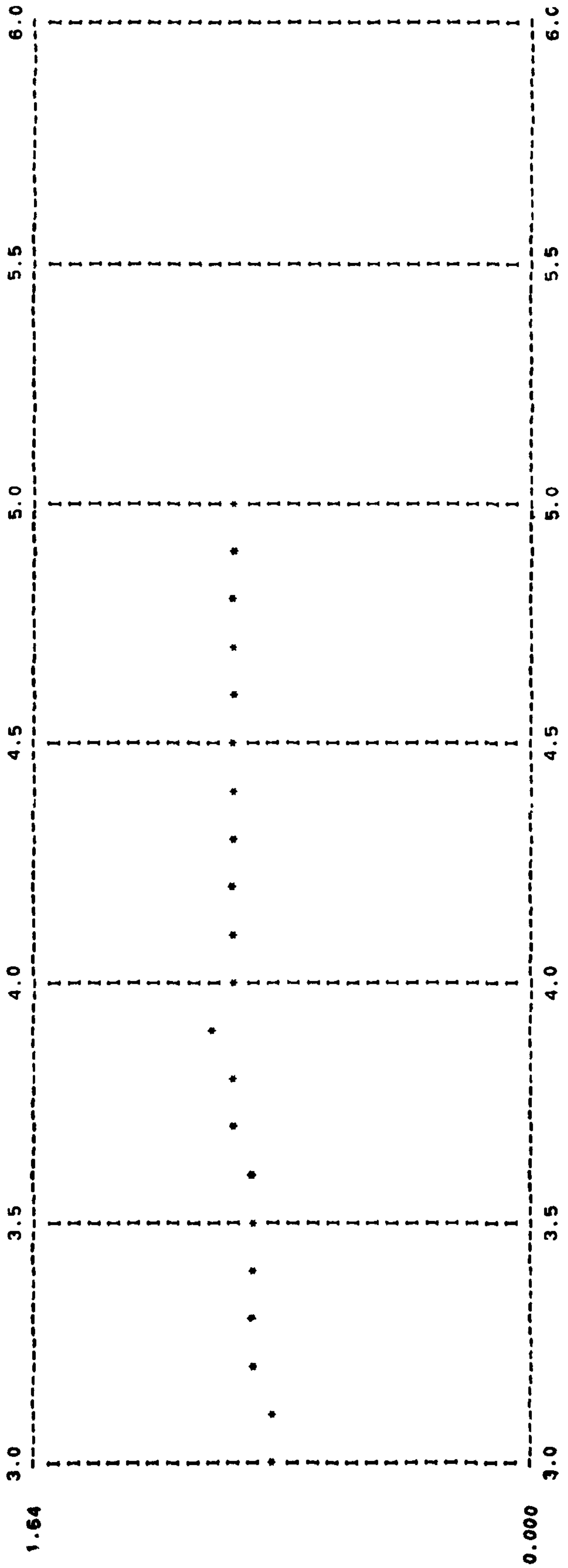
VELOCITY RESPONSE OF STRUCTURAL NODE 37, FREEDOM NUMBER 1:



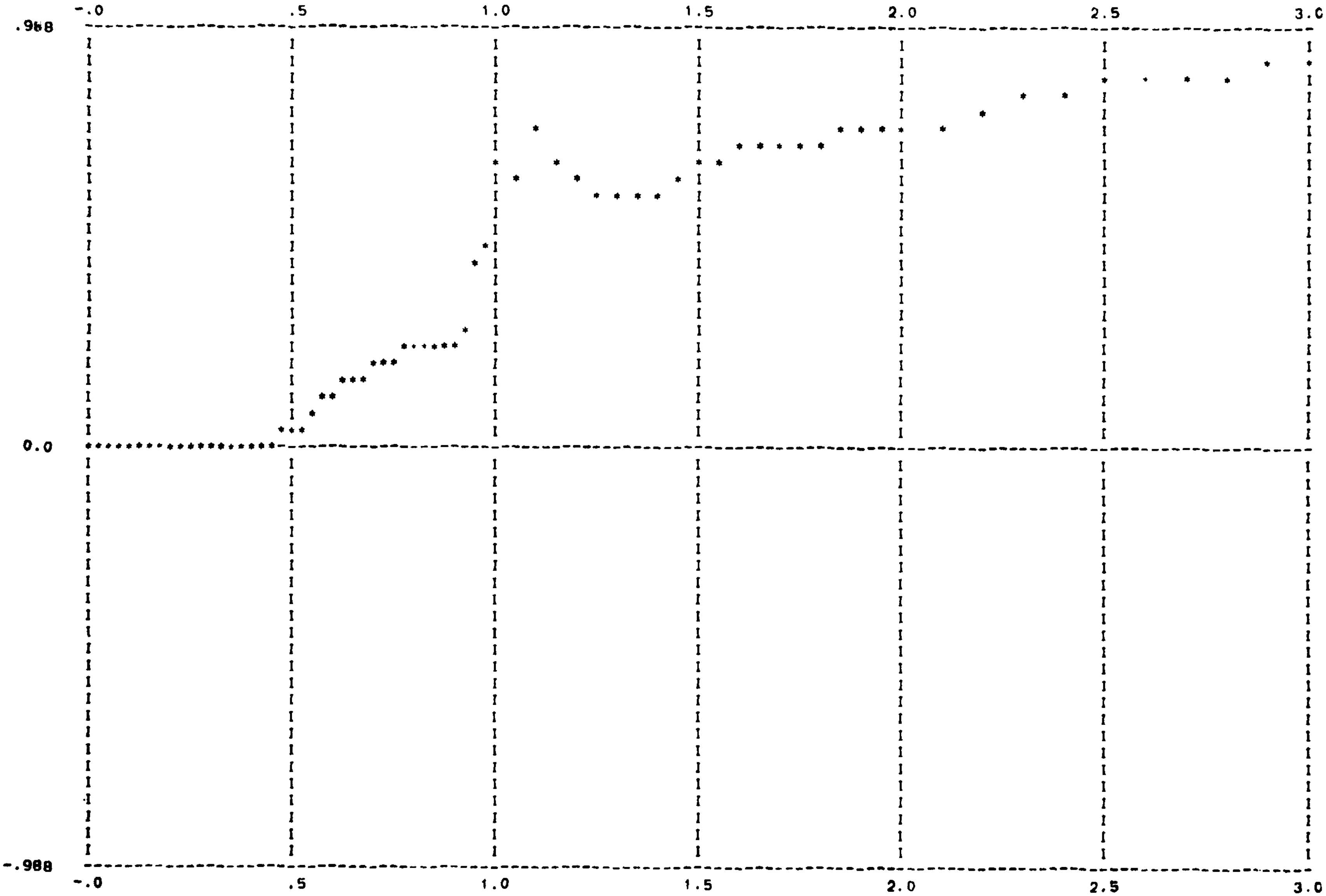

6.0
5.5
5.0
4.5
4.0
3.5
3.0
1.76
0.0
-1.76

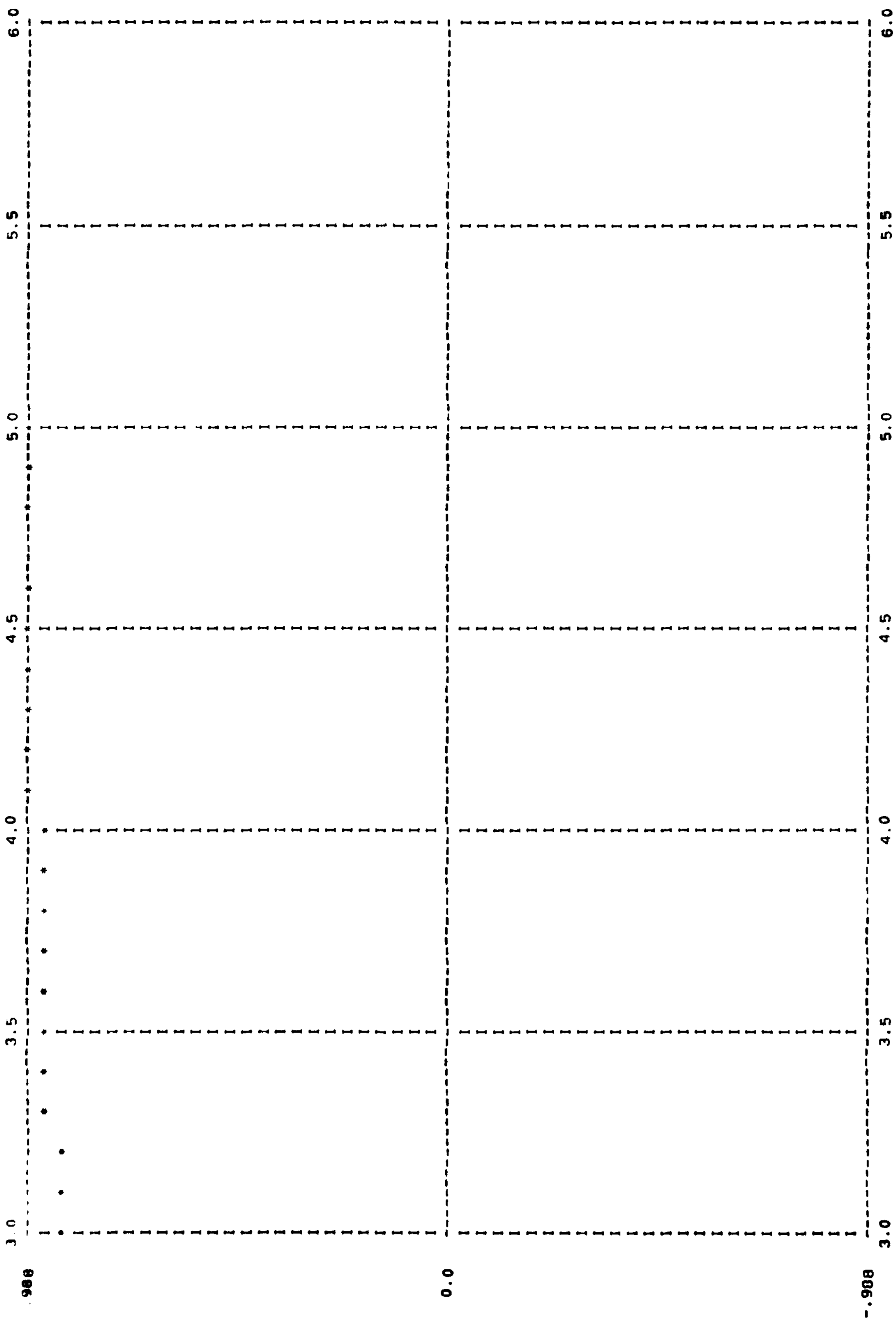
PRESSURE RESPONSE OF FLUID NODE 1:

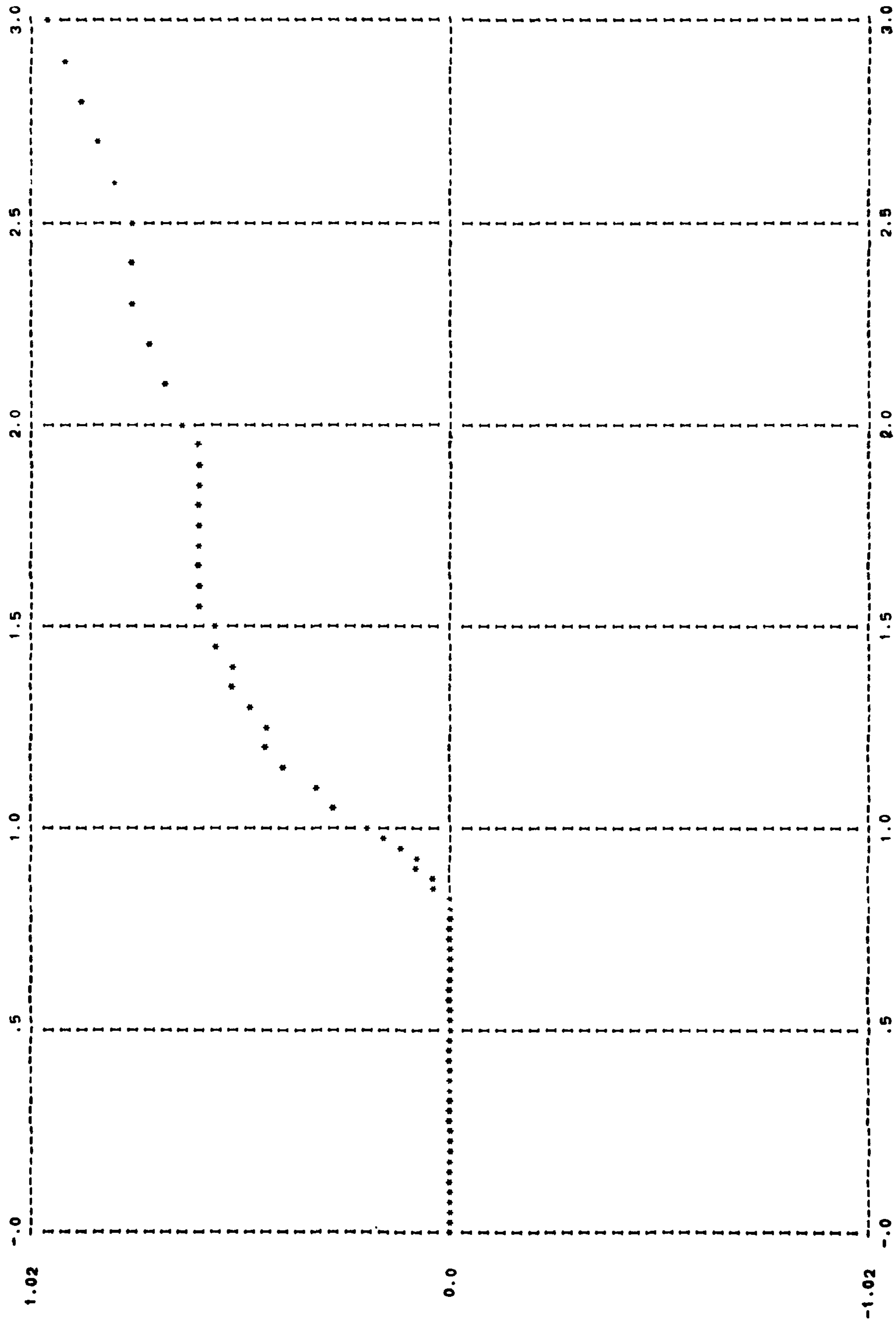



6.0
5.5
5.0
4.5
4.0
3.5
3.0
1.64
0.000

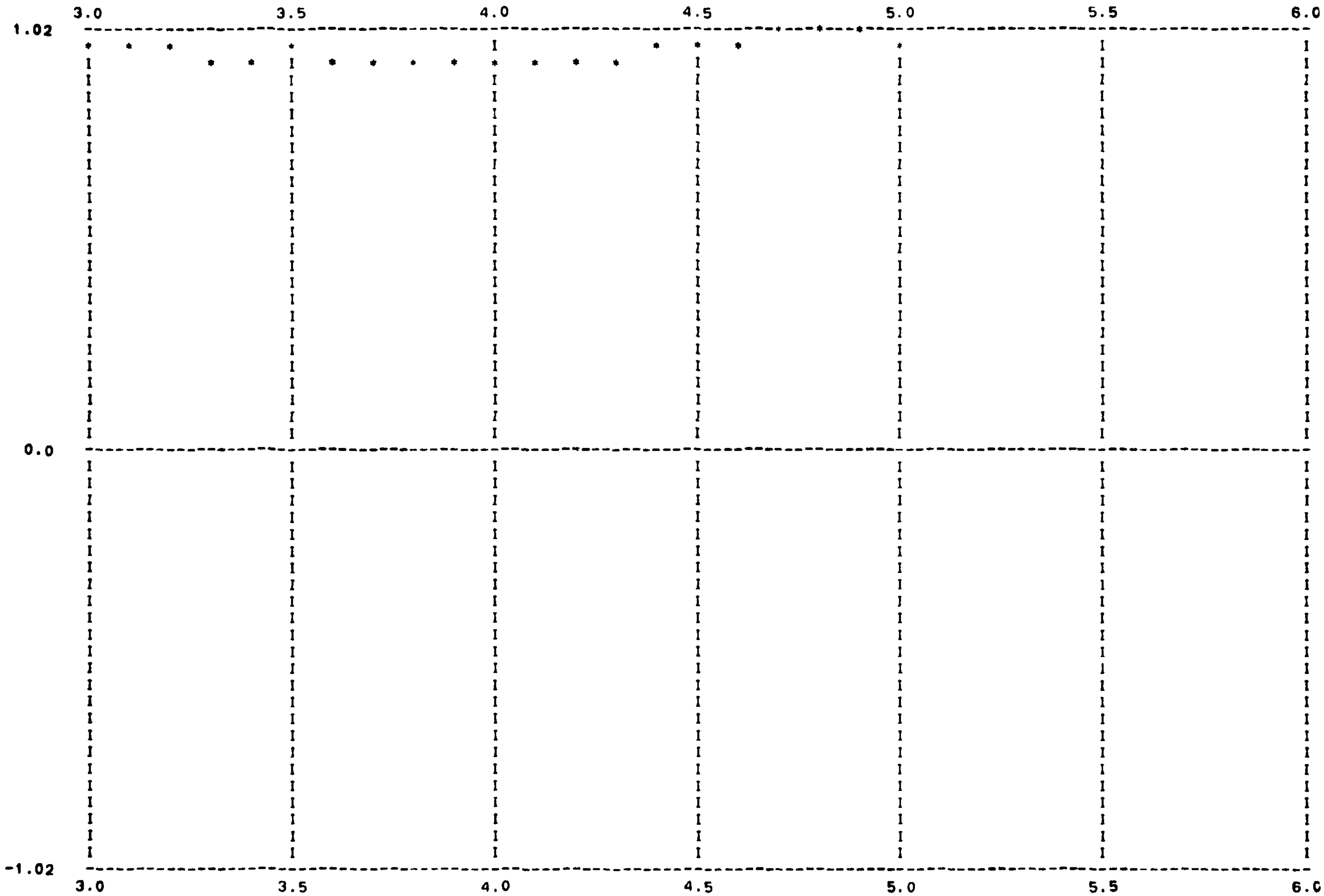
PRESSURE RESPONSE OF FLUID NODE 10:




3.0
3.5
4.0
4.5
5.0
5.5
6.0
908
0.0
-.908



PRESSURE RESPONSE OF FLUID NODE 19:



END DISSPLA -- 22151 VECTORS GENERATED IN 11 PLOT FRAMES.

```
+++  ● ASG,T       UNIT13.              F4/     4/TRK/    256
+++  ● USE      13,UNIT13.

+++  ● FREE        UNIT13.
```

PSEUDO-VELOCITY SHOCK SPECTRA:

	1	2	3	4	5	6	7	8	9	10
F	.00000	.25000-01	.50000-01	.75000-01	.10000+00	.12500+00	.15000+00	.17500+00	.20000+00	.22500+00
1/1 S	.00000	.13015+01	.18346+01	.19198+01	.19773+01	.20304+01	.21882+01	.22248+01	[illegible]	.22059+01
19/1 S	.00000	.42658-01	.84865-01	.12617+00	.16615+00	.20436+00	.26240+00	.32796+00	.40027+00	.49693+00
19/2 S	.00000	.10902+01	.16848+01	.16955+01	.17134+01	.16815+01	.16146+01	.16532+01	.16919+01	.17245+01
37/1 S	.00000	.84337+00	.14352+01	.16059+01	.15199+01	.14705+01	.14021+01	.13259+01	.12536+01	.11990+01

	11	12	13	14	15	16	17	18	19	20
F	.25000+00	.27500+00	.30000+00	.32500+00	.35000+00	.37500+00	.40000+00	.42500+00	.45000+00	.47500+00
1/1 S	.22071+01	.21883+01	.21420+01	.20845+01	.20073+01	.19116+01	.19092+01	.19024+01	.18914+01	.18898+01
19/1 S	.57862+00	.65191+00	.72122+00	.79267+00	.85881+00	.91000+00	.95544+00	.99291+00	.10373+01	.10730+01
19/2 S	.17543+01	.17777+01	.17901+01	.17895+01	.17751+01	.17593+01	.18013+01	.18867+01	.19241+01	.19865+01
37/1 S	.11496+01	.10969+01	.10400+01	.98439+00	.92963+00	.87425+00	.82628+00	.78711+00	.75423+00	.72546+00

	21	22	23	24	25	26	27	28	29	30
F	.50000+00	.52500+00	.55000+00	.57500+00	.60000+00	.62500+00	.65000+00	.67500+00	.70000+00	.72500+00
1/1 S	.18832+01	.18768+01	.18706+01	.18641+01	.18567+01	.18492+01	.18436+01	.19718+01	.20877+01	.21068+01
19/1 S	.10995+01	.11291+01	.11561+01	.11660+01	.11586+01	.11733+01	.11577+01	.11606+01	.11516+01	.11482+01
19/2 S	.21105+01	.22591+01	.24510+01	.26565+01	.27356+01	.27032+01	.26835+01	.25414+01	.23024+01	.20715+01
37/1 S	.63980+00	.67596+00	.65314+00	.63457+00	.61495+00	.59869+00	.58138+00	.56777+00	.55233+00	.53985+00

	31	32	33	34	35	36	37	38	39	40
F	.75000+00	.77500+00	.80000+00	.82500+00	.85000+00	.87500+00	.90000+00	.92500+00	.95000+00	.97500+00
1/1 S	.21707+01	.21364+01	.21060+01	.20917+01	.20136+01	.20154+01	.19027+01	.18825+01	.18212+01	.17731+01
19/1 S	.11428+01	.11445+01	.11511+01	.11557+01	.11500+01	.11497+01	.11503+01	.11422+01	.11258+01	.11251+01
19/2 S	.18423+01	.16583+01	.14814+01	.13497+01	.12825+01	.11917+01	.11157+01	.10798+01	.10619+01	.10419+01
37/1 S	.52795+00	.51479+00	.50382+00	.49443+00	.48414+00	.47298+00	.46473+00	.45749+00	.44950+00	.44107+00

	41	42	43	44	45	46	47	48	49	50
F	.10000+01	.10250+01	.10500+01	.10750+01	.11000+01	.11250+01	.11500+01	.11750+01	.12000+01	.12250+01
1/1 S	.17447+01	.17373+01	.17243+01	.17153+01	.17066+01	.17017+01	.16946+01	.16852+01	.16737+01	.16790+01
19/1 S	.11187+01	.11056+01	.10863+01	.10720+01	.10643+01	.10747+01	.11127+01	.11075+01	.10804+01	.11174+01
19/2 S	.10261+01	.10088+01	.99145+00	.97698+00	.96095+00	.94555+00	.93271+00	.91858+00	.90332+00	.89303+00
37/1 S	.43190+00	.42650+00	.44754+00	.48116+00	.49509+00	.53519+00	.53316+00	.53293+00	.54153+00	.50230+00

	51	52	53	54	55	56	57	58	59	60
F	.12500+01	.12750+01	.13000+01	.13250+01	.13500+01	.13750+01	.14000+01	.14250+01	.14500+01	.14750+01
1/1 S	.17500+01	.18406+01	.18521+01	.18368+01	.18503+01	.18274+01	.17654+01	.17383+01	.16913+01	.16926+01
19/1 S	.10646+01	.10057+01	.10025+01	.97725+00	.95254+00	.92215+00	.87959+00	.84299+00	.85412+00	.83571+00
19/2 S	.88119+00	.86834+00	.85652+00	.84719+00	.83702+00	.82605+00	.81431+00	.80588+00	.79776+00	.78901+00
37/1 S	.50708+00	.46756+00	.43882+00	.40787+00	.37787+00	.36254+00	.35399+00	.34408+00	.34043+00	.33639+00

	61	62	63	64	65	66	67	68	69	70
F	.15000+01	.15250+01	.15500+01	.15750+01	.16000+01	.16250+01	.16500+01	.16750+01	.17000+01	.17250+01
1/1 S	.16380+01	.16203+01	.15931+01	.15666+01	.15621+01	.15555+01	.15500+01	.15424+01	.15348+01	.15243+01
19/1 S	.79080+00	.77590+00	.76058+00	.74503+00	.72938+00	.71376+00	.69829+00	.68306+00	.66815+00	.65361+00
19/2 S	.77964+00	.87876+00	.10787+01	.13339+01	.14075+01	.16466+01	.16833+01	.16262+01	.16919+01	.14572+01
37/1 S	.33197+00	.32719+00	.32205+00	.31657+00	.31079+00	.30472+00	.29839+00	.29507+00	.29187+00	.28844+00

	71	72	73	74	75	76	77	78	79	80
F	.17500+01	.17750+01	.18000+01	.18250+01	.18500+01	.18750+01	.19000+01	.19250+01	.19500+01	.19750+01
1/1 S	.15778+01	.16672+01	.16693+01	.16503+01	.16666+01	.16165+01	.15745+01	.15571+01	.14852+01	.14622+01
19/1 S	.63950+00	.63087+00	.62415+00	.61775+00	.61168+00	.60596+00	.60060+00	.59561+00	.59096+00	.58663+00
19/2 S	.13974+01	.13190+01	.12949+01	.11719+01	.10145+01	.97390+00	.89774+00	.79380+00	.67150+00	.63815+00
37/1 S	.28479+00	.28095+00	.27694+00	.27277+00	.26849+00	.26409+00	.25962+00	.25509+00	.25053+00	.24595+00

	81	82	83	84	85	86	87	88	89	90
F	.20000+01	.20250+01	.20500+01	.20750+01	.21000+01	.21250+01	.21500+01	.21750+01	.22000+01	.22250+01
1/1 S	.14537+01	.14445+01	.14345+01	.14240+01	.14209+01	.14183+01	.14152+01	.14116+01	.14075+01	.14029+01
19/1 S	.58262+00	.57888+00	.57537+00	.57207+00	.56893+00	.56590+00	.56293+00	.55999+00	.55701+00	.55394+00
19/2 S	.62380+00	.61664+00	.61148+00	.60612+00	.60057+00	.59483+00	.58892+00	.58285+00	.57661+00	.57023+00
37/1 S	.24137+00	.23682+00	.23230+00	.22782+00	.22341+00	.21906+00	.21478+00	.21517+00	.20954+00	.21451+00

	91	92	93	94	95	96	97	98	99	100
F	.22500+01	.22750+01	.23000+01	.23250+01	.23500+01	.23750+01	.24000+01	.24250+01	.24500+01	.24750+01
1/1 S	.13978+01	.13966+01	.14620+01	.15059+01	.15438+01	.15346+01	.15189+01	.14572+01	.133[illegible]+01	.13303+01
19/1 S	.55075+00	.54737+00	.54376+00	.53988+00	.53567+00	.53109+00	.52611+00	.52069+00	.51979+00	.52214+00
19/2 S	.56370+00	.55705+00	.55026+00	.54336+00	.53636+00	.52939+00	.52498+00	.52048+00	.61156+00	.67642+00
37/1 S	.21655+00	.22468+00	.25009+00	.26629+00	.27193+00	.26632+00	.26577+00	.31908+00	.30522+00	.29338+00

	101	102	103	104	105	106	107	108	109	110
F	.25000+01	.25250+01	.25500+01	.25750+01	.26000+01	.26250+01	.26500+01	.26750+01	.27000+01	.27250+01
1/1 S	.13208+01	.13305+01	.13171+01	.13148+01	.13136+01	.13092+01	.13059+01	.13022+01	.12983+01	.12953+01
19/1 S	.52430+00	.52623+00	.52789+00	.52924+00	.53025+00	.53089+00	.53110+00	.53088+00	.53017+00	.52897+00
19/2 S	.62761+00	.55835+00	.62454+00	.58268+00	.59824+00	.62315+00	.63313+00	.62501+00	.59934+00	.61225+00
37/1 S	.34231+00	.33014+00	.31353+00	.30259+00	.29097+00	.29788+00	.30175+00	.29532+00	.28257+00	.26980+00

	111	112	113	114	115	116	117	118	119	120
F	.27500+01	.27750+01	.28000+01	.28250+01	.28500+01	.28750+01	.29000+01	.29250+01	.29500+01	.29750+01
1/1 S	.14651+01	.15588+01	.16298+01	.16688+01	.16988+01	.16093+01	.15531+01	.14404+01	.13005+01	.12349+01
19/1 S	.52724+00	.52496+00	.52212+00	.51870+00	.51470+00	.51012+00	.50494+00	.49919+00	.49286+00	.48598+00
19/2 S	.62636+00	.67434+00	.78758+00	.90087+00	.88337+00	.94127+00	.93049+00	.96681+00	.93651+00	.94185+00
37/1 S	.25894+00	.26098+00	.25977+00	.27717+00	.27369+00	.25941+00	.24289+00	.25190+00	.23999+00	.25006+00

	121
F	.30000+01
1/1 S	.12273+01
19/1 S	.47856+00
19/2 S	.97490+00
37/1 S	.25185+00

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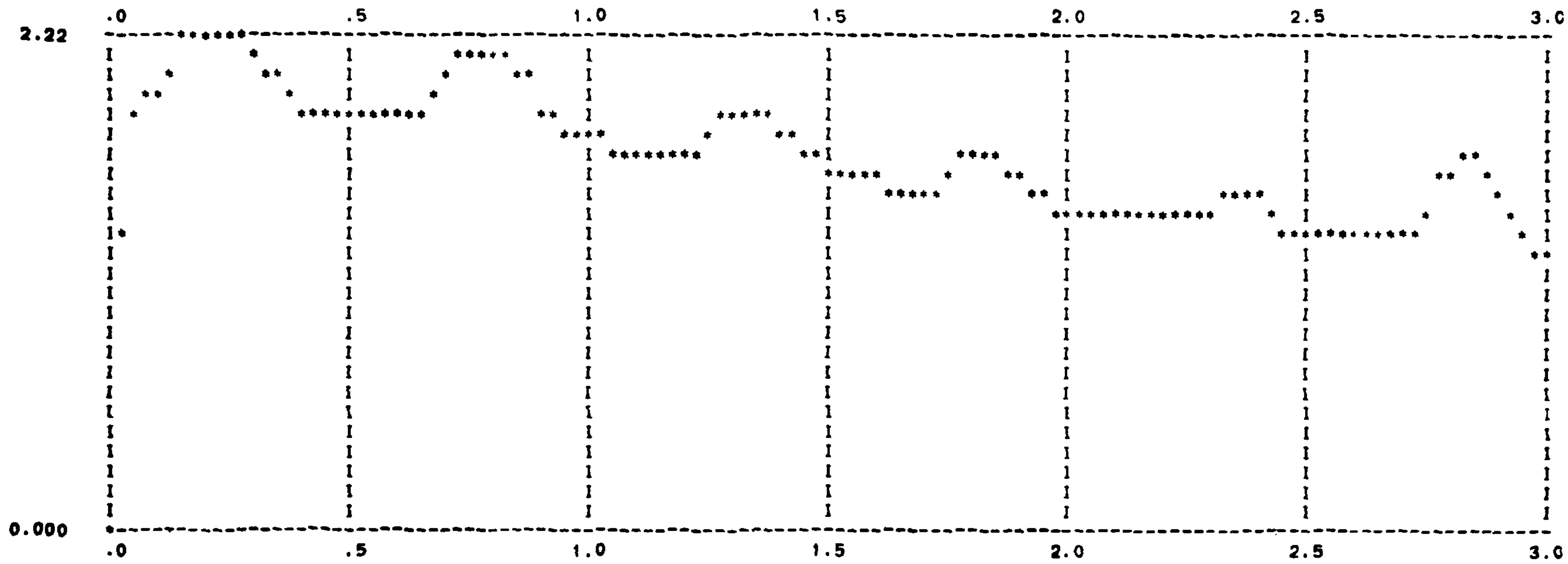

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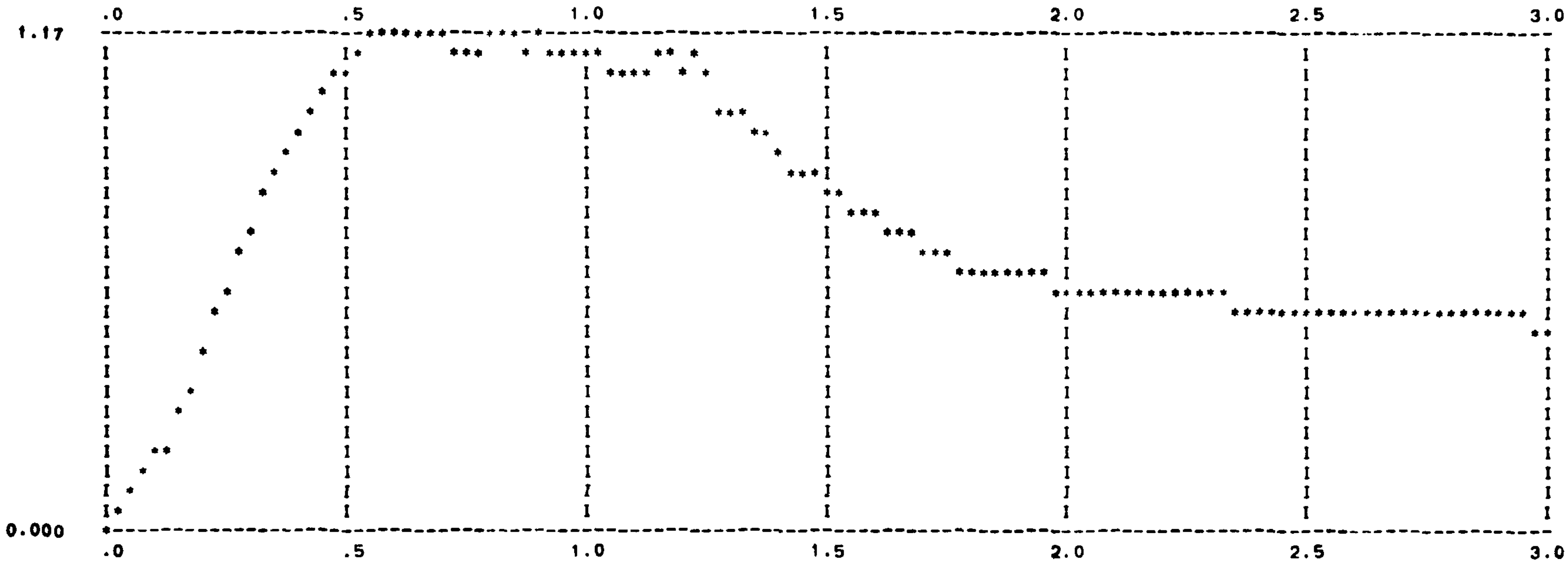

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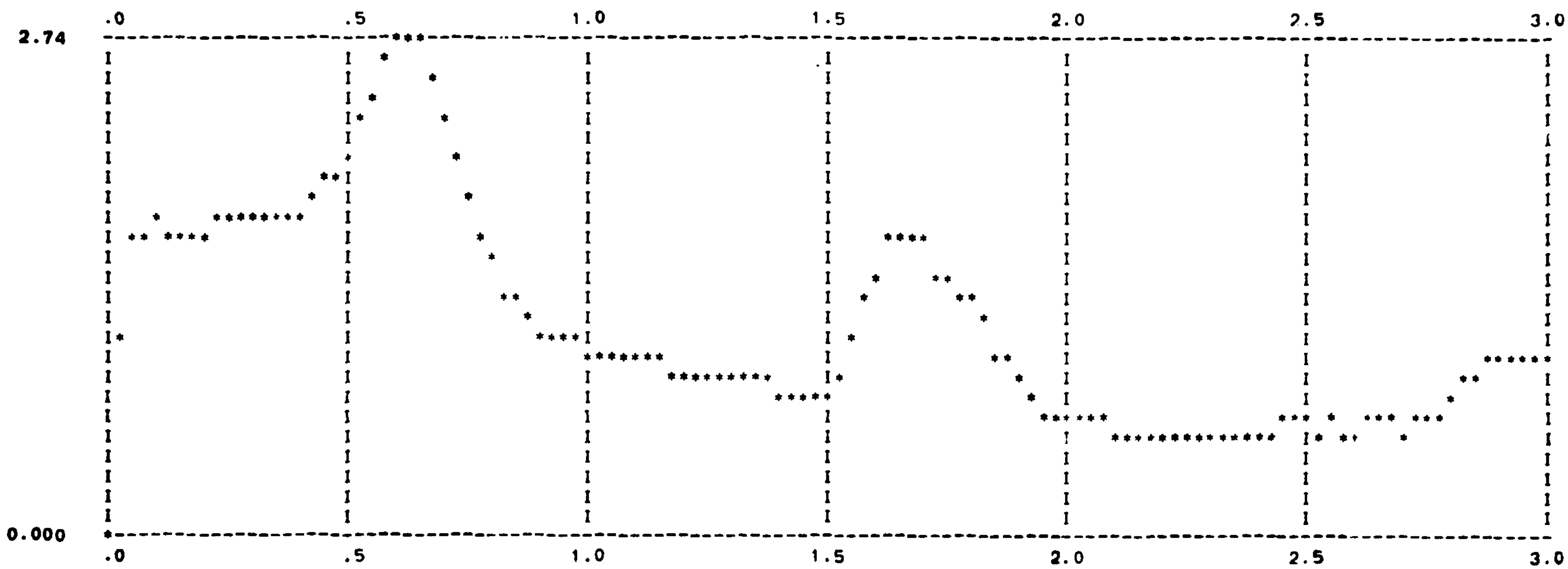

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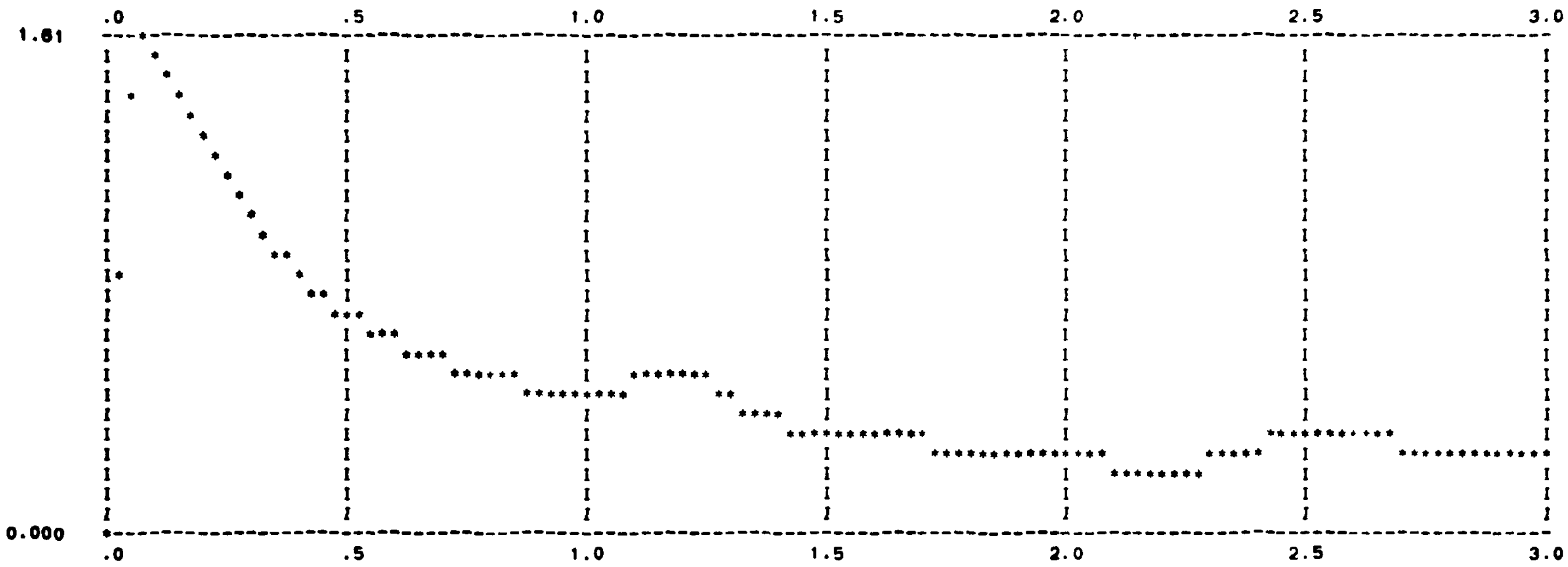


APPENDIX E

USER INSTRUCTIONS FOR INTERFACING WITH USA

To use the Underwater Shock Analysis (USA) Code in its linear stand-alone mode, the user must first construct a permanent data file that contains the structural mass and stiffness matrices and some assorted bookkeeping information. The purpose of this appendix is to describe the structure of the file and to specify how it is to be created. At this time utility routines that carry out this task have been written for SPAR, NASTRAN and GENSAM. An abbreviated form of this file is also required when USA is coupled with a non-linear structural analyzer and such an interface also exists for STAGS.

USA contains the data management utility module DMGASP that carries out all data transfer activities between core and peripheral storage. This is done by unformatted and unbuffered data transmissions and it is imperative that DMGASP be used to create the structural interface file. Otherwise the user must supply or have access to a similar means of direct transfer. Section 3 of [19] contains a comprehensive discussion of the half-dozen or so DMGASP commands that are required to activate, position, write upon, read from, and free a peripheral storage device. Subsidiary commands also exist for error handling and listing of selected information pertaining to auxiliary storage.

The current configuration of USA uses a diagonal mass matrix associated with a lumped mass representation of the structure, assumes that there is no velocity dependent structural damping, and further, only, single precision matrices may be processed. In addition, if the stiffness matrix has been reordered or reduced in any way for input to USA the mass matrix must also be reordered or condensed so that its degrees of freedom (DOF) are the same and appear in the same order as in the stiffenss matrix. Finally, the stiffness matrix must be placed in a multi-block* skyline format as discussed in the SKYPUL manual [23]. This description consists of a Matrix Master Record (MMR) followed by a series of Matrix Value Records (MVR) which contain the numerical values of the matrix. These are the only constructs the user need be concerned with; all others required are already embedded in USA. During construction of the MMR a logical device index (LDI) must be set in the record which USA will access later. For UNIVAC operation, this should be set equal to twenty (20), while for CDC operation this should be set as two (2).

The USA code now includes four routines in the AUGMAT processor that can be used to facilitate assembly of the MMR and the MVR for any symmetric matrix. The routine BLKSKY is used to sequentially call SETPAR which determines the skyline profile, SETMMR which

* For small problems a single block is permissible.

constructs the matrix master record and finally SETMVR which produces the matrix value records. However, the user must ensure that the matrix can be provided row by row (or column by column) with any and all zeroes filled in. Please contact the developer for further details.

The file structure required is shown in Table E-1 where NDOF stands for the number of structural DOF which USA must process. NMMR is the number of words in the matrix master record, and NWBL is the number of words in each matrix value record (which is expected to be the same for each record). NWBL should also be an integer multiple of 448 for most efficient use of storage.

The Grid Point/DOF vector consists of an integer value for each global DOF from 1 through NDOF that is constructed as ten times the external node number plus the local DOF number that apply to that particular structural equation.

For example, if the 87th DOF to appear in the mass and stiffness matrices corresponds to the second degree of freedom at a node identified externally as 4637 then the 87th entry in the Grid Point/DOF vector would be 46372. Local translational degrees of freedom should be numbered 1-3, rotational degrees of freedom should be numbered from 4-6 and any others should be numbered with 7-9. If more than 9 degrees of freedom are carried at any node it is a simple matter to change the factor of ten to one hundred in a few places in USA to accommodate this.

It should be noted that records 1-4 are always accessed by the USA pre-processor AUGMAT before the time integration phase of the analysis commences.* This portion of the file is required for both USA in the linear stand-alone mode, and for USA when it is interfaced with a nonlinear structural analyzer. In this latter case, the fifth and succeeding records do not exist.

There is a minor difference in the way that the fifth and succeeding records are constructed in the SPAR and NASTRAN utilities. In the SPAR interface one pass is made through the stiffness matrix to first determine its connectivity and set up the bookkeeping to construct the MMR. The MMR is then written and a second pass is made through the matrix to write the MVR's immediately following the MMR. In the NASTRAN interface only one pass is made through the stiffness matrix. Hence, the MMR is not constructed until all the MVR's have been written. To follow the order required by Table E-1 space is left in the file for the MMR to be written in its proper order on the file <u>after</u> the entire set of MVR's have been written. Because of this there will generally be a buffer area of irrelevant data (garbage) between the MMR and the first MVR on a NASTRAN file in contrast to a SPAR file.

---

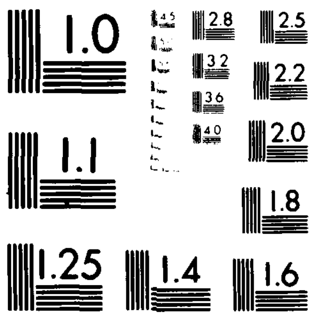
* The fifth and succeeding records can be accessed in AUGMAT if the user wishes to check the stiffness matrix.

Table E-1

Record	Number of Words	Data
1	1	NDOF
2	NDOF	Diagonal Mass Matrix
3	1	NDOF
4	NDOF	Grid Point/DOF Vector
5	1	NMMR
6	NMMR	Matrix Master Record for Stiffness Matrix
7	NWBL	First Matrix Value Record for Stiffness Matrix
.	NWBL	Second Matrix Value Record for Stiffness Matrix
.	.	
.	NWBL	Last Matrix Value Record for Stiffness Matrix

The amount of space currently allowed for the MMR on a NASTRAN skyline file is 10 PRU's (640 words) on CDC and 10 sectors (280 words) on UNIVAC. These values translate into a current limit of 283 and 80 skyline blocks for the two systems, respectively. If more capability is desired the statement MMRPRU = 10 at the beginning of subroutine KDD of the NASTRAN skyline utility can be increased to suit the user's needs.

The SKYPUL processor has the ability to apply constraints due to symmetry or attachment to ground during the time integration. Structural DOF that are to remain zero must have their associated diagonal location pointers (LDP) flagged with a negative sign during construction of the MVR and it is highly recommended that this capability be included in every USA structural interface utility.



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